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DEPARTMENT OF COMMERCE AND LABOR

BULLETIN

OF THE

BUREAU OF FISHERIES

VOL. XXXI

1911

IN TWO PARTS—PART I

GEORGE M. BOWERS

COMMISSIONER

WASHINGTON

GOVERNMENT PRINTING OFFICE

1913

A BIOLOGICAL SURVEY OF THE WATERS OF WOODS HOLE AND VICINITY

In Two Parts

PART I

Section I.—PHYSICAL AND ZOOLOGICAL. By Francis B. Sumner, Raymond C. Osburn, and Leon J. Cole.

✓ Section II.—BOTANICAL. By Bradley M. Davis.

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PART I.

CHARTS.

A BIOLOGICAL SURVEY OF THE WATERS OF WOODS HOLE AND VICINITY.

Section I.—PHYSICAL AND ZOOLOGICAL.

By FRANCIS B. SUMNER, RAYMOND C. OSBURN, and LEON J. COLE.

Chapter I.—INTRODUCTION.

One of the necessary conditions for the intelligent understanding of a nation's population, its resources and its needs, is the taking of an adequate census. So also we can have no proper appreciation of the resources of the sea, and of the means by which we may develop and conserve them without first making an accurate inventory of its inhabitants. This view was stated quite explicitly by Baird (1873, p. XIII) in his first report as Commissioner of Fish and Fisheries, and has been the assumption upon which much of the scientific work of the United States Fish Commission has been based. Accordingly it was appropriate that the first annual report of the commission should contain not only a Catalogue of the Fishes of the East Coast of North America, so far as then known, but an extended report upon the invertebrate animals of one important section of the coast, and a list of the marine algæ inhabiting this same region.

The preparation of these detailed lists of the animals and plants occupying regions of greater or less extent has long been the favorite occupation of a certain class of naturalists. Such lists abound in the annals of botany and zoology. It is only thus, indeed, that we have learned how our planet is populated. The cumulative labors, first of individuals, then of scientific organizations and of governments, have given us the data from which to formulate the laws of geographical distribution. In the beginning we have the bare facts of occurrence; then correlations are established between given conditions of environment and the presence of given species or varieties; finally we are brought within striking distance of the great central problem of the origin of the species.

So much for the scientific aspect of the case. On the practical side, faunistic and floristic studies need offer no apology for their existence. They have, indeed, formed a part of the established policy of our Government for many years. The Department of Agriculture has long maintained a biological survey of the land animals and plants of this continent, while our Bureau of Fisheries, following the example of its illustrious founder, has slowly but steadily been conducting a census of the inhabitants of our seas and lakes. Truly, these creatures are not all fit for food, nor indeed for any commercial purpose whatever—though we must add that there are probably many more animals and plants of economic value than we now realize. But the life of the earth is an interrelated whole. One species stands in relation to another as its enemy, prey, food,

parasite, host, messmate, or the like, and intimate chemical relations may exist, as we find to obtain between the animal kingdom and the plant kingdom, as a whole. Moreover, as we now view the case, all these multitudinous living creatures are, so to speak, related by "blood." The knowledge which we gain from one is commonly applicable to its nearer relatives and frequently to a long series of other forms. Hence the futility of endeavoring, even on economic grounds, to restrict our investigations to food fishes or other animals of obvious commercial importance. What we learn from the study of a minnow is, in the great majority of cases, quite as applicable to a mackerel or a cod. But the minnow is easier to obtain and easier to manipulate. Thus it is that we find a staff of experts, under Government employ, devoting themselves, in many cases, to the study of obscure and apparently insignificant forms of life.

A full account of zoological explorations in the coastal waters of New England would occupy a volume of considerable size. As pioneers in this work stand forth the names of Gould, C. B. Adams, Couthouy, Desor, Girard, and Storer; of Ayres, Stimpson, Mighels, Leidy, and Louis Agassiz. A later period was inaugurated by the establishment of the United States Fish Commission in 1871, and the commencement of the mportant dredging explorations of Verrill and his colleagues. Beginning with the shallower waters of the bays and sounds of New England, these naturalists extended their observations to the broad continental shelf, and finally to the depths of the ocean beyond. The construction by the United States Fish Commission of the steamer *Fish Hawk* in 1879 and of the *Albatross* in 1882 gave great impetus to the exploration of the deeper waters off the North American coast; although work of the first importance in this field had already been done by Pourtales and by L. and A. Agassiz with the Coast Survey steamers *Corwin*, *Bibb*, *Hassler*, and *Blake*, and by Verrill himself with various Government vessels detailed for the service of the Fish Commission.

Many years ago, Woods Hole was selected by Prof. Baird as the most promising spot upon our coast for the commencement of a scientific study of fisheries problems. From the very outset he gathered about him a staff of naturalists of the type that was dominant in that generation—men eager to seek out every living thing concealed beneath the waves, to describe and figure and name. Foremost among these was Addison Verrill, who, with his colleague Sidney Smith and some others, was for many years active in exploiting the marine fauna of New England.

In spite of the previous observations of Desor and Adams and Gould and Stimpson, and the elder and younger Agassiz, who had already made essays into the waters of southern Massachusetts, Verrill and Smith found in Vineyard Sound and Buzzards Bay an almost virgin field. We begin to realize the pioneer nature of much of their work when we recall that even some of our most abundant and familiar species (e. g., *Chalina arbuscula*, *Hydroides dianthus*, *Virbius zostericola*, *Orchestia agilis*) were first described in the Report upon the Invertebrate Animals of Vineyard Sound (1873), while others, including some of our commonest ascidians, had been only recently described by Verrill from specimens taken in the vicinity of Woods Hole. Indeed, the report of Verrill and Smith, hasty and ill digested as it was, remains to this time our chief single reference work upon the fauna of this section of our coast.

That first inclusive list of local species has been much extended, it is true, partly by the original authors themselves, partly by a younger group of naturalists, who have prepared synopses and annotated lists of particular sections of the local fauna. Certain

of these have been published by the United States Fish Commission, others by the National Museum and by the Boston Society of Natural History. So far as they have dealt with the fauna of the Woods Hole region, it is fair to say that these papers are based chiefly, some of them perhaps wholly, upon records or collections made by the United States Fish Commission or by its successor, the Bureau of Fisheries. Within recent years reports have appeared comprising the following groups of animals represented in our local marine fauna [a] Protozoa, Foraminifera, Hydrozoa, Medusæ, Entozoa (of fishes), Copepoda (free), Copepoda (parasitic), Ostracoda, Amphipoda, Echinodermata, and fishes. Others dealing with the local Actinozoa, Bryozoa, and Polychæta are ready for press, and it is the policy of the Bureau of Fisheries to continue this work until every group having any considerable biological or economic importance has been treated in this way.

The task undertaken by the present authors has been twofold: First, to make as complete a census as possible of the marine fauna and flora of an arbitrarily limited region within the vicinity of Woods Hole; and, second, to carry on systematic dredging operations throughout that portion of this region comprising Vineyard Sound and Buzzards Bay.[b]

In carrying out the former division of our work, i. e., the "census," which appears as sections III and IV of this report, we have resorted for data to a variety of sources. First of all we may mention the records of the dredging operations, including, on the one hand, those of the survey, in the restricted sense, and on the other hand the results of many special trips to various points within the region. It must be admitted, however, that out of the grand total of over 1,600 species of animals there listed, scarcely more than 500 are included in the dredging records; while of those species encountered in the dredging operations, the great majority had already been listed by previous writers. On the zoological side, at least, the main source of the data recorded in the catalogue was thus necessarily the literature treating of the local marine fauna. And of this the quantity is very great.[c] For 30 years or more Woods Hole has been the chief station for the pursuit of studies in marine biology on this side of the Atlantic. Fortunately, from the compiler's point of view, a relatively small proportion of the resulting literature contains data relevant to the present work, since the trend of modern biological work is at present physiological and morphological rather than taxonomic and ecological.[d] But the list of papers abstracted for the catalogue of marine fauna and

[a] The papers comprised in the "Fauna of New England" series published by the Boston Society of Natural History are not included here, since they have a different scope.

[b] A brief report upon some of the results of this undertaking was prepared by the senior author of the present work for the Fourth International Fisheries Congress. (Sumner, 1910.)

[c] In addition to making a general search for appropriate bibliographic references, almost to the date of publication of this report, the following periodicals were examined systematically for data relating to the local fauna:

American Journal of Science (from 1870 to 1907).
American Naturalist (from 1875 to 1909).
Biological Bulletin (complete to 1909).
Boston Journal of Natural History (complete).
Journal of Morphology (complete to 1909).
Memoirs Boston Society of Natural History (complete to 1909).
Proceedings Boston Society of Natural History (complete to 1909).
Proceedings Washington Academy of Sciences (1899 to 1907).
Proceedings U. S. National Museum (complete to 1911).
Transactions Connecticut Academy of Sciences (1870 to 1907).
U. S. Fish Commission bulletins and reports (complete to 1909).

[d] A noteworthy illustration of this fact is the paucity of our data regarding the reproductive period of local animals. The meager notes of Bumpus, Mead, and Thompson comprise the larger part of such definite observations as have been recorded on this subject.

flora nevertheless contains more than 250 titles. Moreover, it has not been thought worth while for the purposes in hand to make any very thorough examination of the works preceding the publication of the Invertebrate Animals of Vineyard Sound, since Verrill and his collaborators have there included the rather scanty records of their predecessors. And only such statements were considered by us as relate directly to the occurrence of species within the limits of the region defined hereafter.

Another source of the data accumulated in the course of our "census" was the wealth of information acquired during the past 40 years by the veteran collector of the United States Fish Commission, Mr. Vinal N. Edwards. Much of this, it is true, has already been incorporated into a score of different published papers, with or without due acknowledgment of the real source of the information. It is safe to say that most of the lists and synopses of Woods Hole species that have appeared since the first report of Verrill are based in large measure, if not primarily, either upon records made by Mr. Edwards himself or at least upon material collected by him. The descriptions and, in a large measure, the determination of the species have, however, been the work of others. It was found by us that Mr. Edwards still possessed copious notes relating to the yield of fish traps, fyke nets, seining trips, and tow-net collecting which had never been utilized; and that he had gathered much material which had not yet been identified. Such records have been abundantly employed in the course of our work, and, in general, Mr. Edwards has been continually called upon for information during the preparation of the faunal catalogue. Indeed, one of the motives which originally prompted its compilation was a desire to incorporate in a permanent form the valuable but still unpublished data in the possession of this indefatigable collector and observer.

From time to time notes of value have been contributed by various investigators belonging to the local scientific colony, who have become experts upon one or another group of animals or plants; and in certain cases considerable manuscripts have been furnished us, notably by Messrs. W. R. Coe, J. A. Cushman, W. C. Curtis, C. W. Hargitt, Lynds Jones, Edwin Linton, J. P. Moore, A. L. Treadwell, and C. B. Wilson. Likewise a card catalogue, which had been formerly maintained by the Marine Biological Laboratory as a receptacle for ecological notes, was put at our disposal by the director of that laboratory, and a considerable number of these data were found to be relevant to our purposes. Mr. George M. Gray, the curator of the same institution, has also responded liberally to the numerous queries which we have put to him, and thus we have profited to a large degree from his wide experience as a collector. At the commencement of the present undertaking the practice was encouraged, among investigators in the Fisheries Laboratory, of recording the results of collecting trips of any sort or of observations or discoveries which they might make by chance relating to local ecology. Later a printed form was devised whereby such random records could be entered upon single cards.

Finally, although it was no part of the Survey, as at first planned, to include the littoral or intertidal zone, it was thought desirable to carry on a certain amount of careful shore collecting in order to obtain definite local records for the catalogue. With this in view, parties from the laboratory visited Nobska Beach and Point, Great Pond, Tashmoo Pond, Vineyard Haven, Lagoon Pond, Katama Bay, Cedar Tree Neck, Menemsha Bight, Tarpaulin Cove, Robinsons Hole, Nantucket Harbor, No Mans Land, West Falmouth Harbor, Scraggy Neck, Wareham River, New Bedford Harbor, and Round Hill Point. No such exhaustive inventory was made at these shore stations as was the case with the

dredging work, and lists of the aggregate fauna and flora at these points were not prepared; but definite records of occurrence were obtained in some cases where previously only general statements had been given, and the range of some species was extended in an interesting manner.

The territory covered by the "census" was the entire "Woods Hole Region," to use a rather indefinite and much misused expression. This term, in the present work, is employed in a quite arbitrary sense, as judged from the viewpoint of zoogeography. Generally speaking, the Woods Hole Region has been held to include the entire area of sea and of littoral readily available for collecting purposes from Woods Hole as a base. Of course such an area comprises a great diversity of conditions, and supports a most diverse fauna and flora. In compiling the census the criterion generally employed in admitting or rejecting species was as follows: Records were admitted from points extending from Newport on the west to Chatham and Sankaty Head upon the east. Narragansett Bay, except that portion in the immediate vicinity of Newport, was excluded; but the whole of Buzzards Bay, Vineyard Sound, and Nantucket Sound were included, together with the ocean shores of Marthas Vineyard and Nantucket and the adjacent ocean area southward to the 20-fathom line. It is not a part of our present purpose to define and delimit the Woods Hole Region for future investigators. There is, of course, no such region geographically speaking. Unfortunately this term, and even the name Woods Hole itself, have been used by various writers in an extremely misleading sense. Certain species have been listed in published records as taken at "Woods Hole" which we know to have come from considerable distances. In the case of certain fishes, indeed, it is quite evident that they were bathysmal species, collected at great depths and far from land.

The second part of our undertaking comprises the systematic dredging operations which were conducted during the summers of 1903, 1904, and 1905, together with supplementary work carried on during the four following seasons. This project has been very generally referred to as the "Biological Survey of the Woods Hole Region," and this term is a convenient one, provided that too much is not implied by it; for this has obviously been a biological survey in a rather limited sense. Neither the plankton nor the exclusively littoral (intertidal) fauna and flora are included within the scope of the operations in question, though abundant data relating to these are, of course, included in the "census."

The Survey, in this restricted sense, has been confined to Vineyard Sound and Buzzards Bay, with the exception of one day's dredging at Crab Ledge, near Chatham. The Crab Ledge records, having been made with nearly the same degree of care and thoroughness as those made in strictly local waters, have been included within the limits of the present report, though otherwise they would not have been regarded as relevant to it. As will appear later, this procedure has made possible some most interesting and instructive comparisons.

During the early explorations of Verrill in the waters adjacent to Woods Hole little system, or at least little regularity, seems to have been employed in the choice of dredging stations. Certain lines were followed, it is true, whose position appears to have been known with some definiteness, and the dredge was lowered at more or less regular intervals. These stations all appear upon the chart which accompanies his report (The Invertebrate Animals of Vineyard Sound); but there is little if any reference

to specific stations in the text of that report. From the earliest days of the United States Fish Commission, when naval tugs and other small Government craft had to be requisitioned to meet the needs of its scientific explorations, down to the days of the *Fish Hawk* and *Albatross*, it has been the custom to record serially numbered dredging stations, with the bearings, depth, and other data by which each spot could be identified. From time to time lists of these stations have been published (Smith and Rathbun, 1882; Sanderson Smith, 1889). Thus far, however, no lists have ever been offered showing the total array of species found at the various stations, nor has the distribution of a single species been described in detail or plotted out graphically for local waters. Whether or not the data necessary for such an undertaking were ever gathered in the past, they have never been published, and those earlier records are scarcely available at present.

For this reason it seemed desirable to repeat the earlier exploration of the shallower waters in the vicinity of Woods Hole, in an endeavor to deal with certain problems more intensively than has ever been done before. A systematic survey of the bottom of Vineyard Sound and Buzzards Bay was accordingly planned, with a view to showing (1) the aggregate fauna and flora associated together at each point dredged; (2) the detailed distribution of each species which was found; and (3) the depth, character of bottom, temperature, etc., which might explain the observed facts of distribution. The incidental discovery of new species would, of course, be welcomed, though this was not the primary object of the investigation.

In the dredging work the steamers *Fish Hawk* and *Phalarope* were chiefly employed. With the former vessel much larger dredges could be used, and the position of the stations could be determined more accurately. The *Phalarope*, on the other hand, having a smaller draft and being more wieldy, could be employed in shallower waters. This vessel was consequently the one used for the inshore work, both in the Bay and the Sound, though the still smaller *Blue Wing* was employed on a few occasions.

Three types of dredging apparatus were employed by us. (1) The beam trawl, of which descriptions and figures may be found in several previous reports of the United States Fish Commission (Verrill, 1883; Tanner, 1884, 1897). The trawls employed in the present work were quite diminutive in comparison with those used in commercial trawling, having a beam length (width of aperture) of from 6 to 9 feet, and a depth of net not much exceeding 10 feet. This appliance can be employed to best advantage on a level bottom of hard sand or fine gravel, upon which the lead line fits closely. It is well adapted to scraping up the larger mollusks, fishes, crustacea, echinoderms, algæ, etc., which lie upon the surface, but not to penetrating the sand or gravel; and it consequently fails to disturb those forms which burrow in even a slight degree. For this reason, and because of the large size of its meshes, the beam trawl was commonly not employed alone; but a dredge of the next type was ordinarily appended to the lower end of the bag.

(2) The ordinary naturalists' dredge, of the type originally devised by O. F. Müller (see Verrill, 1883; Tanner, 1884, 1897; Agassiz, 1888). This, as is well known, consists of a heavy, rectangular, iron frame, to which is fitted the mouth of a bag of stout netting. In the commoner pattern the two longer sides of the frame consist of sharp, outwardly flaring edges, adapted to cutting into the sand, gravel, or mud; and the

dredge is practically certain to drag in such a way that one or the other of these edges is lowermost.

A modification of this type of dredge which was freely used during the present work was the "rake dredge," which differs from the ordinary pattern in possessing heavy teeth along the cutting edge. The frame, in both types, is fitted with two heavy movable iron arms, to which the dredge line is attached. Commonly a comparatively light rope was fastened to one of these handles, so that in case an obstruction was encountered this line might part and allow the dredge frame to free itself without escaping altogether. The dredge net was protected from tearing by a sheathing of heavy canvas, which was attached to the frame outside of the net and formed a bag, open at the lower end. The netting commonly employed in these dredges had a ½-inch or a 1-inch mesh[a] in the upper portion, while the lower end was quite closely woven. Such meshes were likely to retain not only the stones, shells, and the great majority of living organisms, but even considerable quantities of the bottom material. Fine loose sand, however, and in less degree mud, were likely to be washed out almost completely during the reeling in of the dredge line. Where such bottoms were encountered, the canvas sheathing of the dredge was frequently tied up at the lower end, or sometimes a simple canvas bag alone (mud bag) was attached to the frame. During the last season of the regular dredging work (1905) the mud bag was nearly always employed in connection with the beam trawl. It is obvious that a much fairer bottom sample could be collected in this way. The dimensions of the frame in the type most commonly used during the *Fish Hawk* dredging were 12 by 22 inches. A smaller size (8 by 16 inches) was, however, sometimes used in the *Phalarope* and *Blue Wing* work.

(3) The third type of dredge employed was the "oyster dredge." This was intermediate in size between the beam trawl and the scrape dredge and was very heavily constructed, being well adapted to use upon rocky bottoms. The scraping edge at the mouth of this implement was armed with powerful spikes or teeth, designed to dig deeply into the sand or gravel. The bag of the dredge was made up of iron rings, linked together after the fashion of chain armor. In order to retain the smaller organisms, this chainwork bottom was commonly lined with fine netting. The oyster dredge was employed on bottoms too stony for the other appliances, or where it was desired to penetrate more deeply beneath the surface.

The *Fish Hawk* is a steam vessel having a length of 146 feet at the water line, or of 156 feet over all, a beam of 27 feet, and a draft of about 7 feet. She carries adequate machinery for the reeling in of heavy dredges, and despite her limited speed and unseaworthy construction is an extremely serviceable vessel for scientific operations in quiet waters. A full description of the *Fish Hawk* has already been given by Tanner (1884), and therefore need not be repeated here.

The material taken by the *Fish Hawk* dredges was commonly emptied into a series of trays, constituting the table sieve of Verrill and Chester (Verrill, 1883), having graded meshes, the coarser ones naturally being uppermost. After a superficial examination and preliminary search for specimens a stream of salt water was played upon the material, and the sand, mud, and small unattached organisms were thus washed into the

[a] These measurements refer to the "stretched" mesh. Such meshes would be ¼ inch or ½ inch square when open.

underlying, smaller-meshed trays. The contents of each tray were examined in turn, according to a system to be described later.

The Tanner sounding apparatus[a] was employed at each of the *Fish Hawk* stations, together with the Sigsbee "water specimen cup," and the Negretti-Zambra thermometer. Thus the temperature and density were recorded, as well as the depth of the water. It was later realized, however, that the figures for temperature and density obtained during the regular dredging operations were not sufficiently exact for the purposes of the work, and, likewise, that no fair comparison would be possible of the different waters in the region unless we possessed a set of determinations which had been made nearly or quite simultaneously throughout its entire extent. For this reason a new set of temperature and density observations, taken with standardized instruments and within the briefest period possible, was made after the completion of the dredging work. Such determinations were repeated several times at intervals of a few months, so that the seasonal conditions are now pretty well known. These will be discussed in a later section.

The position of the vessel was determined in the earlier part of the work by means of an azimuth compass located on the roof of the deck house, just abaft the pilot house. Bearings were taken upon two, sometimes three, landmarks, usually lighthouses. This was commonly done just before the lowering of the dredge. The "station," as recorded on the chart, was thus the point where the dredge haul commenced, while the direction and amount of the drift was estimated rather roughly.[b] Later, tripods were erected upon a number of Coast Survey triangulation points and sextants were employed in locating the ship's position. Angles were taken simultaneously by two observers, one of whom found the angular distance between X and Y, the other that between Y and Z. The position of the vessel was determined both at the beginning and at the end of the dredge haul, and frequently at one or two intermediate points. Thus upon the maps the later stations in Vineyard Sound appear not as single circles but as straight or curved lines, at intervals in which are to be found the points (a, b, c, etc.) at which sextant readings were taken.

The *Phalarope* is a steam vessel, originally designed as a yacht, having a length of 82 feet at the water line, or of 92 feet over all, and a beam of 16 feet. She draws 7½ feet of water, and her average speed is probably about 11 knots. The *Phalarope* carries no dredging machinery and is not permanently equipped for this work. In landing the dredge a small derrick was employed, this being operated by hand power. The contents were emptied upon a special movable platform built over the forward cabin. A set of sieves was employed similar in principle but smaller than those used on the *Fish Hawk*. With this vessel the use of the beam trawl was impracticable, and even the oyster dredge was too heavy to be employed very frequently, though it was used to advantage under certain conditions. The second type of dredge mentioned above was therefore the principal one employed.

Since the *Phalarope* dredging was, for the most part, done within a quarter of a mile from land, it was found to be possible to locate the stations with a fair degree of accuracy by reference to features of the shore. Bearings upon lighthouses were not commonly practicable, nor indeed were they believed to be especially desirable. The soundings indicated, with sufficient precision, the distance from land, and the direction

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[a] For descriptions and figures see Tanner (1884, 1897).

[b] This last has been omitted from the 1903 records.

of various landmarks was noted. An ideal degree of accuracy in locating these stations might have been attained through the sacrifice of much time and effort, but it is doubtful whether the scientific value of this report would thereby have been greatly enhanced.

In the case of both vessels the same general procedure was adopted in respect to the listing and the preservation of material. One or more of the authors of this report accompanied each dredging trip, and one or several assistants were detailed from the laboratory staff. On many occasions specialists interested in particular groups of organisms accompanied us on these expeditions and participated in the identifications. The more obvious and easily recognizable species were listed on the spot, mention being made of their relative abundance and other facts of interest. These observations were dictated to an assistant. At the same time samples of the sand, stones, mud, seaweed, etc., and any specimens concerning which the least doubt was entertained were preserved, with a record of the station from which they came. This material was later sorted over in the laboratory and further species were identified and listed. Those concerning which there was still any doubt were bottled and subsequently referred to the proper specialists. Formalin was commonly employed for fishes, mollusks, coelenterates, and worms, alcohol (after the earlier dredgings at least) being generally used for crustacea, bryozoa, and echinoderms, the calcareous parts of which, as is well known, are damaged by formalin.

The authors of the zoological section of this report early familiarized themselves with a large proportion of the commoner species encountered, including the great majority of larger animals, and after a few preliminary safeguards it was believed that any one of us could identify these with a fair approach to certainty. Minute organisms, or any which required careful study before they could be specifically determined, were either subjected to careful examination in the laboratory by the authors themselves, or, more commonly, were reserved for reference to one or another of the taxonomic experts who have assisted us.

Acknowledgment must here be made, accordingly, to the specialists who have given their services, in most cases without any remuneration, to the task of identifying the Survey collections. The following deserve mention: Dr. Paul Bartsch (mollusks), Dr. R. P. Bigelow (decapods), Dr. H. L. Clark (echinoderms), Prof. W. R. Coe (nemerteans), Dr. J. A. Cushman (Foraminifera, Porifera, Ostracoda), Dr. W. H. Dall (mollusks), Dr. B. W. Evermann (fishes), Dr. J. H. Gerould (sipunculids), Prof. C. W. Hargitt (coelenterates), Prof. S. J. Holmes (amphipods), Dr. B. W. Kunkel (amphipods), Prof. F. M. MacFarland (nudibranch mollusks), Dr. J. P. Moore (annelids), Prof. C. C. Nutting (hydrozoa), Dr. H. A. Pilsbry (barnacles), Miss M. J. Rathbun (decapods), Dr. Harriet Richardson (isopods), Prof. W. E. Ritter (simple ascidians), Mr. R. W. Sharpe (copepoda), Dr. W. G. Van Name (compound ascidians). The part played by each of these specialists will be referred to in connection with the various divisions of the animal kingdom. A few insects, most of which were taken during the shore and brackish-water collecting, were identified by a number of entomologists in the National Museum.

In the case of certain groups it was found impossible to obtain any assistance from previously trained specialists, or at least to the extent needed for the complete identification of our collections. In such cases it became necessary for one or another of the authors of this report to acquire a certain degree of mastery of the group in question. This has been true particularly of the Bryozoa, Cirripedia, Amphipoda, Isopoda, and Pycnogonida.

The identification of the first-mentioned group of organisms was undertaken by Dr. Osburn, who, as a result, has been led to the preparation of a synopsis of the Bryozoa of this section of our coast. Dr. Osburn likewise disposed of the isopods collected by us after the first season's work. The pycnogonids and a large proportion of the amphipods from our dredgings were identified by Dr. Cole, while Dr. Sumner has given considerable time to an examination of the barnacles of the survey. The study of the Foraminifera, Porifera, and Ostracoda was first undertaken by Dr. Cushman, while employed as a salaried assistant in the Woods Hole Laboratory during the progress of the survey. In respect to the second-named group, his identifications are admittedly somewhat tentative.

The determination of the marine algæ was carried out by Prof. B. M. Davis and Miss Lillian MacRae, one or both of whom accompanied nearly every dredging expedition belonging to the regular series. Doubtful cases were referred to Mr. F. S. Collins, to whom our thanks are likewise due in this place.

Various types of printed cards and other blank forms have been employed in the course of this work. (1) A large sheet 12½ by 16 inches, of which an incomplete reproduction appears below. Upon this were transcribed the original dredging records, made in the field and in the laboratory.[a] The array of species for each station was here given, together with various relevant notes.

This form was drawn up and adopted before the commencement of the dredging operations and before the requirements were definitely known. Experience has very naturally suggested changes. The columns headed "Sexual condition," "Age or size," and "Special habitat" might better be dispensed with, since such data can only be properly recorded for each dredge haul separately, and the column headed "Total" is likewise of no use. Furthermore, there should have been ten columns instead of five devoted to dredging stations, since more than five dredge hauls were commonly made during a single day's work. It might also be worth while, in another edition of these sheets for local use, to print the names of the species which occur most frequently in the lists.

COLLECTING RECORD.[b]

Locality.............................. Date.............................. Observers..............................

							Remarks.
Time of day..............	Number of set or haul, etc.	1	2	3	4	5	
Tide..............	Locality, in degs. and mins.						
Weather..............	Depth..........						
Air temperature..............	Character of bottom.						
Wind..............	Water temperature, surface.						
Prior conditions..............	Water temperature, bottom.						
Method of collecting..............	Density of water.						

Species.	Sexual condition.	Age or size.						Total.	Special habitat.	Remarks.

[a] The copying of these records was largely the work of Messrs. D. W. Davis and Max Morse.

[b] In the form actually used there was space for a large number of species.

(2) From an analysis of these large sheets the distribution of each species was ascertained. The list of stations for each of these species was recorded serially upon large blank cards 5 by 8 inches in size. Here were entered, along with each station number, the abundance, where stated, or any item of interest which had been noted in the original records.[a] These cards, under each major group, were arranged alphabetically and kept for reference. The distribution of each species by stations could thus be determined on a moment's notice.

(3) A sheet 8 by 11 inches in size was devised, having the headings indicated herewith. This was intended either for use in abstracting data from various published records, or for the entry of information furnished directly by observers. A single sheet was devoted to each species so listed, and the printed headings are self-explanatory. These sheets were padded in blocks of 50 each.

RECORD BLANK FOR NOTES UPON LOCAL SPECIES.

Observer's name..

Name, specific..
Name, popular or local..
Relative abundance..
Distribution, geographical (state any locality where species is known to occur)..
Distribution, seasonal (with exact dates, in case of rarer species)..
Habitat (host, if a parasite)..
Reproduction (sexual condition, breeding habits, etc.)..
Food..
Method of collecting..
Economic data..
References in literature (to local occurrence only)..
Remarks (any ecological or other data of interest. May be continued on back)..

(4) A rather elaborate system of cards was devised for recording in permanent form the summarized data derived from all of the sources detailed previously. Separate cards 4 by 6 inches in size were printed, with headings corresponding to each of the subdivisions of the sheet just described (3). The name card was of heavier material and provided with a projecting index margin, or "tab" intended to bear the specific name. Thus a complete record for a single species would consist of 11 cards, although, as a matter of fact, this number would seldom be used, owing to the lack of certain data. In addition, a heavy red index card was provided for each family, and a blue one for each class. A large mass of data was transcribed upon these cards in typewriting, but it must be confessed that the system was found to have serious faults in practice. In the first place, it was, as should have been foreseen, too cumbersome. In the second place, data were entered on different cards which should not have been separated. For instance, "relative abundance" should not commonly be separated from "geographical distribution," since it often happens that a species may be abundant in one locality and very rare at others. The phrase "scarce to abundant" does not describe such a situation with sufficient precision. In a similar manner "habitat" and "season," or date, should be included with each individual entry of the occurrence of a species. The total number of cards per species should evidently be greatly reduced. Nevertheless, the system, even as described, served a useful purpose during the preparation of this report; and it is

[a] The burdensome task of transcribing these records was carried out with great care and precision by Mr. C. V. Morrill.

recommended that a simplified card catalogue be maintained at the laboratory in the future for the reception of further data as they accumulate. Such a system, if properly cared for, would furnish a receptacle for fragmentary notes and records which otherwise would be lost.

(5) For occasional or random observations by local observers a provisional mode of entry was adopted and another type of card, uniform in size with the last, was printed for the purpose. This card, although likewise capable of improvement, proved to be extremely useful.

We trust that the following explanations and admissions will not be construed as an apology for the results herein offered. Without such a frank confession of the limitations of our work and of the difficulties encountered, we should expose ourselves to the criticism of making pretensions which have not been realized. It is only fair to ourselves that we should disarm such criticism as is based upon the assumption that we have enjoyed greater facilities and opportunities than was actually the case. Moreover, fairness and scientific accuracy demand that there be a clear separation between those of our results which we regard as clearly established and those which are to be regarded as merely probable. The reader's confidence in what we trust are really substantial and valuable acquisitions should not be shaken by the discovery of various undeniable sources of error and uncertainty.

The fact must be emphasized at the outset that the work of the Survey, with a few important exceptions, was restricted to the summer months. The vessels employed were commonly available not earlier than July 1 and not later than September 1. This is likewise the period during which those immediately in charge of the dredging operations were free for work of this sort. Without exception, the biological staff was constituted by university or college men—instructors or graduate students—who were busily occupied in their teaching or their studies for about nine months of the year.

From these circumstances there has resulted a two-fold limitation of the work. First, with respect to the dredging results, we can only offer a record of midsummer conditions; second, it is obvious that neither as much work nor as high a degree of preparation can be expected of a staff thus constituted as from one composed of naturalists permanently engaged in pursuits of this sort. We must confess in all frankness that we found it necessary in large degree to develop our own methods through experience, and that the earlier dredging operations are to be regarded as in large measure practice work. This fact, however, has been recognized by the authors throughout, and for this reason the field of these earlier labors was explored later with far greater care and thoroughness.

Due allowance must likewise be made for the fact that those of us who listed and sorted the dredging material in the field and in the laboratory make no pretensions to being universal naturalists having a "speaking acquaintance" with practically every species of animal and plant likely to be encountered by us. We will add the further admission that on many occasions no one of the party thus employed was a recognized authority upon a single group of animals, considered from the standpoint of taxonomy. But this state of affairs has resulted, we believe, almost wholly in errors of omission, many of which have been subsequently rectified. At the outset we familiarized ourselves with those species which were readily recognizable, and endeavored to learn in just what cases confusion was possible and special care necessary. The advice of

various systematic zoologists who happened to be at the laboratory was constantly sought. Specimens from each dredge haul of all species concerning which any doubt was believed to be possible were brought back to the laboratory for further examination, and were commonly bottled for reference to specialists. Some confusion of species probably occurs in the records here presented, especially those derived from the earliest dredging work; but we believe these cases to be few, and we have endeavored to indicate such possibilities in their proper place in the records. Moreover, the supplementary dredging trips to be mentioned below have removed many of these ambiguities.

Cases of omission are doubtless present in great frequency, and many of them would have been inevitable under the most favorable circumstances. Microscopic organisms were entirely overlooked. The Foraminifera were collected and listed during only one of the seasons in which the original "stations" were dredged. The smallest crustacea and worms, and in fact minute organisms in general, were undoubtedly overlooked in very large measure. Certain forms were regularly neglected during the earlier portions of the work, but were later sought for and preserved, after our attention had been called to them by special students of the organisms in question. This was particularly true of some of the more minute hydroids, Bryozoa, amphipods, and Annulata. The charts representing the distribution of such forms would consequently be misleading unless this fact were taken into consideration. The apparent absence of a species throughout a wide area would not in such cases imply its actual absence. But here again we have indicated such possibilities in the discussions of the various groups. In a large proportion of cases an example of a doubtful species was preserved from each station at which it occurred. Sometimes, however, a single specimen was chosen as representative of a considerable number of stations. This proved to be a dangerous practice. It has sometimes happened (most often, perhaps, in the case of encrusting Bryozoa and of certain small mollusks) that the representative sample proved to comprise two or more species. The identity of the species which had been taken at the other stations was, of course, rendered uncertain. Such ambiguities are duly noted in the records, as also other possible sources of error and confusion.

Again, certain misleading results have arisen from the differences in the dredges employed at various points. So far as these relate to the character of the bottom they will be discussed under that head. It need only be pointed out here that the beam trawl alone would bring up no bottom sample except occasional stones, and would thus miss most of the organisms except the larger algæ and such animals as crawl upon the bottom or at least project considerably above its surface. On the other hand, the scrape dredge alone, on account of its small aperture, would commonly miss the fishes and other actively swimming organisms, and, indeed, would have a much smaller chance of gathering in any of the forms which dwell freely on the bottom. The burrowing species, however, or such, at least, as do not burrow deeply, would commonly be captured. At the majority of the *Fish Hawk* stations, as already stated, the two were used together or in succession.

During the earlier part of the work the bottom material (sand, gravel, shells, etc.) was not searched with sufficient care, and considerable numbers of species were doubtless overlooked for this reason. Later more careful methods were adopted, such as have already been described.

Errors have doubtless crept in during the copying and tabulating of the records. It will be readily appreciated that the clerical work herein involved was enormous and that it was necessary to intrust much of it to assistants. Although methods of corroboration and verification were commonly employed, and while we believe the records to be reasonably free from errors of this sort, instances have been discovered of regrettable carelessness on the part of certain assistants employed during the earlier stages of the work. But the total number of such cases is in all probability proportionately very small; and they commonly can not seriously vitiate the results, since the most frequent errors made have been the transpositions of the records of adjacent stations. In no case can such a mistake have resulted in assigning to the fauna of our region a species which has not been found here, or even in the confusion of records from widely different points within the area dredged.

And, finally, it must be pointed out that even our highest authorities are not infallible and that they do not in all cases appear to have been consistent in the determination of species.

But after making all these admissions—and honesty demands that they should be made—we insist emphatically upon the substantial accuracy of the results herein presented. We have made due allowance for the various sources of error and have, in many cases, been able to correct them by supplementary work. Indeed, during every season since the conclusion of the original survey dredging trips have continually been made with a view to rectifying specific errors. To what degree these supplementary dredgings confirm the earlier results and to what degree they reveal inaccuracies or omissions will be pointed out later. We have been most fortunate in having the active cooperation of more than a dozen systematic naturalists of high standing, without whose assistance, indeed, this work would have been utterly impossible.

While, then, more and better work could have been done under ideal but impossible conditions, we think that no apology is necessary in offering the results already accomplished. We are able to portray with a fair approach to accuracy the detailed distribution of a large number of species of plants and animals and are able to portray with less completeness the distribution of a much greater number. We have been able to correlate, in a large number of cases, the peculiarities of distribution with peculiarities in the character of the bottom or with the temperature of the water, and to compare in an interesting way the distribution patterns of closely related species. And, finally, we believe that we have laid a foundation upon which others may build in the future. And here a few words as to the needs of the future may not be out of place. As it does not seem likely that those who have been most active in the present undertaking will be able to devote much more of their time to it, we venture to offer the following tentative program to our possible successors:

(1) A repetition of this entire dredging work after the lapse of 10 or 20 years would be highly desirable. We should recommend relatively less attention to Vineyard Sound and relatively more to Buzzards Bay. This later work could doubtless be accomplished more rapidly than was done in the present case. The mistakes and failures of the present report could perhaps in considerable measure be rectified. Such a repetition of the present survey would not improbably reveal interesting changes in the occurrence of various species, and it doubtless would result in supplementing and correcting our rather experimental labors.

(2) Seasonal changes in the fauna and flora should be determined by observations throughout the year.

(3) A more definite system of classifying bottom deposits is desirable. (See p. 30–32.)

(4) Temperature and density records should be taken throughout the entire region for every month of the year.

(5) The intertidal and the pelagic fauna and flora should receive the same detailed attention as has been accorded to the bottom-dwelling species.

(6) The limits of the area dredged should be extended from the mouth of Buzzards Bay and Vineyard Sound out to the 25-fathom line, and farther if practicable. Such work as has already been done points to the possibility that the limits of distribution of a considerable number of species would be successively encountered as the work was extended outward. We should likewise predict in full confidence a greater and greater predominance of such northern types as just enter Vineyard Sound and Buzzards Bay.

We hope that such a program may be carried out in the future. Much of it could only be accomplished, it is true, by the establishment of a permanent scientific staff at the Bureau's Woods Hole Laboratory. Our hope, therefore, embraces this feature likewise.

The senior author of this report, as director of the Woods Hole Laboratory, has had general supervision of the Biological Survey from its inception, including executive management, selection of assistants, correspondence with specialists, etc. Upon him, also, has fallen the duty of compiling the results and of writing the entire report, excepting that portion devoted to the marine algæ. The latter has been prepared by Dr. Davis. On the other hand, both Dr. Osburn and Dr. Cole have played an essential part in this undertaking, and are fully entitled to rank as joint authors.

During the summer of 1903, in which the *Fish Hawk* alone was used for the Survey dredgings, the field work and subsequent disposition of the zoological material were in direct charge of Dr. Sumner and Dr. Osburn. In 1904 the *Fish Hawk* dredging, after a few preliminary trips, was in charge of Dr. Cole, who was likewise largely responsible for the identification of the material collected by that vessel. During the latter season the inshore dredging with the *Phalarope* was commenced, and this, almost from the outset, was in charge of Dr. Osburn, who identified a large proportion of the specimens and drew up the records for these trips. During the summer of 1905 practically the same arrangements were continued, Dr. Osburn superintending the work of the *Phalarope* and Dr. Cole that of the *Fish Hawk*. Thus the two last-named members of the staff have been responsible for about four-fifths of the field work during the first three seasons of the Survey dredging, together with a proportional amount of the task of identifying the zoological specimens, while perhaps one-fifth of this is to be credited to Dr. Sumner. This estimate leaves out of consideration the services of the botanists of the staff, Dr. Davis and Miss MacRae, who participated in the field work during the second and third seasons of the survey.

The supplementary dredging trips of later seasons were in charge of different members of the laboratory staff, according to the nature of the material sought. During the summers of 1907 and 1908 Messrs. D. W. Davis and C. B. Bennett were each detailed for duty on the *Fish Hawk* for a considerable number of days, with instructions to search for and preserve all material belonging to certain specified groups. The sorting and

subsequent disposition of these specimens fell to the lot of Dr. Sumner. The temperature and density determinations of August, 1907, were conducted by Mr. D. W. Davis, the series of November, 1907, and of March and June, 1908, being carried out by Dr. Sumner. The temperature records of August, 1909, for Nantucket Sound and Crab Ledge were obtained by Dr. Osburn and Dr. Cole. The systematic shore collecting already referred to was almost wholly in charge of the two last-named persons, each supported by a number of assistants detailed from the laboratory, while a careful examination of the fauna of certain brackish ponds of the region was undertaken by Dr. E. D. Congdon.

A really complete list of those who are entitled to rank as collaborators in the work of the Survey or in the preparation of this report would include a larger number of names than could well appear upon the title-page. Our indebtedness to Mr. Vinal Edwards has already been expressed, and the services of certain assistants have been acknowledged in the discussion of various phases of the work. No inconsiderable credit for such success as has attended our efforts must be given to the commanders of the vessels employed during the dredging operations. Especial mention must be made of the able services of Boatswain James A. Smith, United States Navy, and Lieut. Franklin Swift, United States Navy, commanding in successive years the steamer *Fish Hawk*, and those of Mr. Robert N. Veeder, commanding the *Phalarope*.

A list has already been given of those who have aided in the determination of species, and reference has been made to the fact that certain of these experts accompanied many of the dredging expeditions, or at least examined the material immediately after its arrival at the laboratory. Thus Messrs. Bigelow, Cushman, Hargitt, and Moore, and Misses Rathbun and Richardson were each present at the Woods Hole Laboratory during one or more of the seasons devoted to the Survey operations.

Acknowledgment must here be made of the cordial cooperation and willing help of the foregoing persons and a number of others throughout the preparation of this report. Each portion of the annotated list, or "catalogue," has been referred to a specialist for the revision of the nomenclature. In the main, the list given on page 19 might be repeated with the following qualifications: To Dr. Dall has been referred the portion of our list relating to the Mollusca, with the exception of the nudibranchs and the Pyramidellidæ, concerning which Dr. F. M. MacFarland [a] and Dr. Paul Bartsch, respectively, have been consulted. To Miss Rathbun alone we have referred the manuscript relating to the local decapods; to Prof. Hargitt alone that relating to the cœlenterates; and to Dr. Holmes alone the list of amphipods. Certain specialists not hitherto named have likewise been kind enough to criticize the classification and nomenclature in the case of various groups not represented in the dredging collections. Those deserving mention are: Dr. G. M. Allen and Dr. Lynds Jones (birds), Prof. G. N. Calkins (Protozoa, other than Foraminifera), Prof. Edwin Linton (parasitic flat worms and round worms), Mr. R. W. Sharpe (free living copepods), Dr. Leonhard Stejneger (reptiles), Dr. F. W. True (mammals), Prof. C. B. Wilson (parasitic copepods).

In the case of certain minor groups the authors of the report must themselves assume responsibility for the nomenclature employed, this being based upon the best published work available. Some discussion will be devoted to the subject of classification and nomenclature in the section dealing with the annotated list.

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[a] Dr. MacFarland has gone so far as to prepare for us a synopsis of considerable length, including the Woods Hole nudibranchs.

From October, 1906, to December, 1909, the senior author of this report was almost continuously in residence at Woods Hole, engaged in the task of compiling the data and preparing the results for publication. The great amount of skilled clerical work herein involved has been largely performed by Miss Edith Chapman and Mr. James W. Underwood, whose patience and conscientiousness throughout these monotonous labors deserve ample recognition. For the accuracy of each step in the task of compilation, however, the senior author makes himself fully responsible. The manuscript of the present report has been read over and discussed by all of the authors and is to be regarded as expressing our substantially harmonious views.

The next chapter will consist of a preliminary discussion of the various physical factors which affect the marine fauna and flora of the region. A chapter will then be devoted to a statistical analysis of the results of the Survey, as well as of the census of animal species. Next, the various groups of animals will be discussed separately and in greater detail. Following this an attempt will be made to interpret some of the phenomena herein discussed, and to show the bearing of our results upon some of the broader problems of biology. There will then follow, in order of arrangement, a list of the regular dredging stations of the Survey, the faunal distribution charts and the physical and geographical charts.

Section II will consist of a presentation of the chief results on the botanical side, followed by the distribution charts for the marine algæ. Sections III and IV will comprise the faunal and floral catalogues or annotated lists. Rather full bibliographies have been appended, comprising works relating to the occurrence of the various animal and plant species at Woods Hole.

There would have been much in favor of considering the fauna and flora together throughout the present report, and particularly in the general discussions relating to distribution. Since, however, the day of the universal naturalist has passed, and since each one of us must content himself with being either a zoologist or a botanist, it has not seemed practicable to throw together the discussion of the entire "biota" of the region. The botanical portions of the work, as well as the field work upon which they have largely been based, represent the labors of botanists who have worked, to a considerable degree, independently of the zoologists of the staff. Thus we have thought it advisable to present the results as far as possible separately. This arrangement likewise corresponds to the difference in authorship between the two main subdivisions of the work.

The introductory chapter, together with that upon environmental conditions, are, however, just as essential to an understanding of the botanical data as of the zoological, and the geographical and physical charts are likewise equally related to both subdivisions of the report. Thus the entire report is, in a sense, a unit, and indeed the zoological and botanical members of the staff have conferred to a considerable extent during its preparation.

Chapter II.—GEOGRAPHICAL AND PHYSICAL CONDITIONS.

1. GEOGRAPHY.

The general geographical features of the region may be seen at a glance by reference to charts 223, 224, and 225[a]. Vineyard Sound has a length of from 15 to 17 nautical miles, depending upon the limits arbitrarily chosen,[b] and a width of from 3 to 6 nautical miles. Its main axis bears from northeast to southwest. The southeastern boundary is constituted by the island of Marthas Vineyard, the northwestern by the Elizabeth Islands and for a short space by the mainland of Cape Cod. At its eastern end Vineyard Sound passes imperceptibly into the far wider Nantucket Sound, while to the westward it opens freely to the Atlantic Ocean. It is connected with Buzzards Bay by a series of narrow straits, of which Woods Hole is a type. Through them the tidal currents are very swift. These straits separate the Elizabeth Islands from the mainland and from one another. There are no streams of any consequence emptying into either Vineyard Sound or Nantucket Sound.

Leaving out of consideration certain shoals and the zone immediately adjacent to the shore line, the depth throughout Vineyard Sound ranges between 6 and 18 fathoms, most soundings lying between 10 and 15 fathoms. There is in no sense a progressive deepening of the water as we pass toward the western end of the Sound, although some of the greatest depths (18 fathoms[c]) occur in the vicinity of Gay Head and Cuttyhunk. At least one sounding as great as this has, however, been made back of Middle Ground Shoal, and depths as great as 17 fathoms occur at more than one point in the eastern half of the Sound. As a rule, the 10-fathom line runs within a half mile from shore, though mention must be made of an elongated shoal reaching well toward the middle of the Sound and extending throughout about half its length. This is known at its eastern end as the Middle Ground, the opposite end being called Lucas Shoal. In the former portion the water may be no deeper than 4 feet or less in depth at mean low tide.

Buzzards Bay has a length of about 25 nautical miles, as measured from the railway station known as Buzzards Bay to the Hen and Chickens Shoal. Its main axis is nearly parallel to that of Vineyard Sound, from which it is separated throughout the lower half of its length by the Elizabeth Islands. Elsewhere it is bounded by the mainland of Massachusetts. At its northern end and along its entire western side the shore line of Buzzards Bay is very irregular, being indented by a considerable number of estuaries,

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[a] These and other geographic and hydrographic charts used in the present report are the work of Mr. W. F. Hill, formerly draftsman in the Bureau of Fisheries.

[b] The region explored during our dredgings extends a short distance into what would probably be commonly regarded as belonging to Nantucket Sound, though there is, of course, no definite line of division between the two.

[c] Our own soundings give 19½ fathoms at one point (*Fish Hawk* station 7683), while the greatest depth indicated on the Coast Survey chart for Vineyard Sound is 18 fathoms at mean low tide. Perhaps the phase of the tide is partly accountable for this difference; perhaps it rests upon an error of observation. The depth recorded by us for station 7682 (19 fathoms) is quite likely due to an error. Otherwise no serious discrepancies have been detected between the *Fish Hawk* soundings and those of the Coast Survey. In general our soundings (*Fish Hawk* and *Phalarope*), while not always taken with great care, are believed to be close enough approximations, especially when the variability in depth throughout the extent of the Bay and the Sound are considered.

which penetrate deeply into the mainland. Some of these, as will be shown later, furnish considerable quantities of fresh water at certain times of the year. The depth of Buzzards Bay beyond the "adlittoral" zone (see p. 179) ranges from 3 fathoms near its head to 18 or more fathoms at its mouth. About a mile west of Penikese Island occurs a deep hole only recently charted. Here a depth of 24 fathoms has been found, this being, so far as known, the deepest sounding obtainable within a distance of 10 miles or more from land. Throughout most of its extent, however, Buzzards Bay is much shallower than Vineyard Sound, and a depth of 10 fathoms is seldom or never encountered except near its lower end.

The conditions existing in Buzzards Bay and Vineyard Sound can not be understood without reference to the adjacent features of the coast and the ocean. The tidal currents, as well as the character of the water, are doubtless influenced by the proximity to the westward of Narragansett Bay and Long Island Sound. From the mouth of Vineyard Sound the Atlantic Ocean, throughout an arc of about 120°, extends for an indefinite distance uninterrupted either by land or by shoals. The depth, on the whole, increases very gradually, the "continental shelf" extending out to a distance of over 75 miles to the southward of Gay Head, where the 100-fathom line is encountered. Shortly thereafter an abrupt descent commences. South of Marthas Vineyard the 20-fathom line lies 10 miles or more off shore, and the distance increases as we pass to the westward. South of Narragansett Bay, however, it sends a long slender loop in a northeasterly direction toward the mouth of Vineyard Sound, reaching a point within about 6 miles of Gay Head.

To the east and southeast of Woods Hole the geographical conditions are peculiar, and are highly important in determining the nature of the fauna and flora on this part of the coast. The peninsula of Cape Cod, together with the two large islands to the southward, inclose a broad, shallow body of water—Nantucket Sound. This attains a high temperature during the summer months, and doubtless in large degree influences the temperature of Vineyard Sound, with which its waters mingle freely as a result of tidal currents (p. 36). It is possible, also, as has been held by certain writers, that Cape Cod, together with Nantucket and its associated shoals, constitute a barrier which deflects a well-defined cold ocean current away from the mainland of the continent. Whether or not this is true, it is an undoubted fact that the coastal water temperatures to the east and north of Cape Cod are much lower during the summer months than are those immediately to the south of it. The resulting faunal differences will be discussed elsewhere, and the temperature conditions will likewise be considered more fully in another place.

2. CHARACTER OF THE SHORES AND BOTTOMS.

The dominant feature of the shores and bottoms along this section of the coast is the glacial débris. Although the main outlines of the land topography of this region may be preglacial, as Shaler (1898) contends, there are extensive morainal deposits upon Nantucket, Marthas Vineyard, and the Elizabeth Islands, as well as on neighboring parts of the mainland. Indeed, a large part of the local shore line and sea bottom still consists of practically unaltered glacial boulders and gravel, which have been subjected for only a comparatively brief period to erosion and transportation by waves and currents. Even the Middle Ground in Vineyard Sound is regarded by Shaler as "a bit of

submerged land topography," and not as the creation of currents acting upon shifting sands. Sandy beaches are common upon the ocean shores of Marthas Vineyard and Nantucket, where the surf is heavy and erosion is known to be progressing rapidly. Elsewhere within our region stones and gravel are a characteristic feature of the shore line. Commonly, this coarser material extends down the beach to low-tide mark or beyond, being succeeded by a gently sloping sand flat, more or less interspersed with scattered stones and boulders. In places where the shores are not too steep the stony belt gives place on its landward side to a sandy beach of varying breadth, or the littoral zonation may at times be even more complex. On the other hand, there are many tracts of shore where this phenomenon is not manifest at all, the entire shore and the adjacent sea bottom, so far as visible, being wholly stony. Mud, largely of organic origin, occurs in abundance in bays and inclosed waters which are not swept by tidal currents.

At certain points within our area preglacial formations have become exposed. As the most conspicuous instances of this we may cite the cliffs of colored clay at Gay Head and the outcroppings of granitic rock in the vicinity of New Bedford Harbor. These last represent a formation "which probably in large part constitutes the foundation rocks beneath the sea and under the islands which lie to the north of Marthas Vineyard." (Shaler, 1888, p. 323.) This formation is the probable source, according to Shaler, of the glacial bowlders of Marthas Vineyard. Passing reference may be made here to Shaler's hypothesis that Buzzards Bay and Vineyard Sound each represents the submerged valley of a former river. It does not lie within the province of this report, however, to consider the various problems relating to local geology.[a]

As regards bottom characters, Vineyard Sound and Buzzards Bay stand in striking contrast to one another. In the former, stones, gravel, and sand predominate; in the latter, mud. These differences are very readily explained. Vineyard Sound is constantly swept by strong tidal currents, which prevent the accumulation of fine deposits except in sheltered bays, such as Tarpaulin Cove and Menemsha Bight. Buzzards Bay, on the other hand, being open only at the lower end, is not subjected to such a thorough scouring by the tides (see p. 37), and here, therefore, large deposits of mud occur, as, indeed, they do at all points on the sea bottom off shore at depths which are beyond the influence of currents. Moreover, there open into Buzzards Bay a number of rather large estuaries, which doubtless furnish much of the material which becomes deposited as mud. It has been shown that silt so fine as to remain for a long period in suspension in fresh water is soon precipitated when mixed with sea water. (Allen, 1899, p. 380.) Thus it is evident that a considerable part of the suspended material from the brackish-water estuaries which empty into the northern and western parts of Buzzards Bay must settle to the bottom before it can be transported to any great distance.

One of the data recorded at each dredging station was the nature of the bottom so far as revealed by the sample brought up. The classification was a very rough one, and it must be freely confessed that it could have been greatly improved. The following were the principal ingredients recognized: (1) Sand; (2) gravel (referred to as "pebbles" when fine); (3) stones; (4) shells; (5) mud. These ingredients occurred singly or in almost any combination.

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[a] The reader is referred to Shaler's two papers already cited.

Referring to the first three heads, it must be stated that the ordinary glacial drift of the region, like that which is distributed so widely elsewhere, consists of a mixture, in varying proportions, of sand, gravel, and stones. These three terms are not employed in the same definite sense as they are, for example, by E. J. Allen (1899). This writer restricts the word "sand" to mixtures of particles the coarsest of which will pass through a 1½ mm. sieve, the finest passing through a ½ mm. sieve, but not remaining in suspension for more than one minute in sea water. Under this main class he recognizes three subdivisions. "Gravel" (also subdivided into "fine," "medium," and "coarse") comprises aggregations of particles ranging from 1.5 mm. to 15 mm. in diameter. Any inorganic material coarser than this was listed by him as "stones." Our use of these terms, though far less precise than Allen's, we believe to correspond more nearly with common usage. In many cases our "sand" would probably comprise Allen's finer grade of "gravel," and our "gravel" would comprise much which he would term "stones." Thus stones which were frequently as large as an inch or more in diameter were considered as belonging to the "gravel."

The truth is that any such classification is arbitrary, and, unless actual measurement is employed, as has been done by Petersen and by Allen and Worth, these designations must be extremely ambiguous. Moreover, it is very doubtful whether an exact classification, such as the foregoing, would be of any service in the case of our local sea bottoms, which vary so much, even within the limits of a single dredge haul.[a] As will be pointed out later, the nature of the methods employed renders it possible to state with only a rough degree of approximation the extent of the correlation between the distribution of a given species and the character of the sea floor.

Another source of difficulty relates to the character of dredge employed at a given station. A canvas bag (p. 17) would retain all of the ingredients, and this could be washed and sifted and properly described. Such a small bag would frequently fill almost immediately, however, and thus fail to represent the entire course of the haul. During the earlier portion of the work the sample was commonly collected by an ordinary dredge net having a very close mesh at the bottom. It is obvious that if the mixture consisted of sand and gravel, much of the former might be lost during the reeling in of the dredge line, and that the sample might be listed as merely "gravel," whereas sand predominated at the outset. On the other hand, a sample in which sand predominated was doubtless at first often listed as "sand" in cases where careful washing would have revealed the presence of small proportions of gravel or shells. The beam trawl, having no cutting edge, and having a net with a wide-meshed bottom, would bring up merely the loose stones lying freely upon the surface. Thus the "stony" bottoms of the earlier records may in some cases have included a certain proportion of sand and fine gravel, though such cases are probably infrequent, since the beam trawl was commonly not used upon bottoms known to be stony. Where no stones appeared in the trawl net it was usually assumed, in the absence of data to the contrary, that the bottom was sandy. However, as already stated, a small dredge was generally used along with the beam trawl.

[a] An idea of the variability in the character of the bottom within comparatively narrow limits will be gained from considering the results of some of our supplementary dredgings, in the course of which over 100 of the original stations were repeated with a rather rough approach to accuracy. On comparing in each instance the earlier and later record for the same station it was found that in only 14 per cent of the cases were identical types of bottom recorded, while in only 33 per cent of the others were they substantially identical. In 47 per cent of the cases the ingredients recorded were partly the same, while in 6 per cent they were totally different. The later entries were as a rule fuller than the earlier ones, and this fact doubtless accounts for some of the differences, but they are likewise largely the result of real differences in the bottom passed over.

Large beds of nearly pure sand are without doubt common in Vineyard Sound, and are occasionally met with even in Buzzards Bay. Such are the great shoals of shifting sand of which Middle Ground in Vineyard Sound is a fair sample. These are veritable submarine deserts, often being almost devoid of life. Despite Shaler's assertion that in Vineyard Sound "the amount of sand at the disposition of the currents and waves is not large," we believe that such transportation is sufficiently active in some localities to be a determining factor in distribution. In the vicinity of Middle Ground and Lucas Shoal we have frequently observed the water to be rendered turbid by sand and fine shell fragments which had been brought up by the currents from a depth of several fathoms.

Beds of dead shells, accompanied by sand, gravel, or mud, occurred frequently, both in the Bay and in the Sound. These sometimes represented extinct mussel beds, though the shells of *Spisula solidissima*, *Arca transversa*, *Venus mercenaria*, *Venericardia borealis*, *Astarte castanea*, *Callocardia morrhuana*, *Anomia simplex*, *Pecten gibbus*, and other lamellibranchs sometimes occurred in great quantities. Among the gastropods, *Crepidula fornicata* is perhaps the only one which contributed materially to shell deposits, although the shells of many of the commoner species, occupied by hermit crabs, are frequently taken in great numbers.

Under "mud" is included a considerable diversity of material, differing in origin and in chemical composition, but agreeing in consistency and in general appearance. In a few cases the deposits represented upon the chart by the conventional shading for mud are fairly pure clay. Beds of this last material occur, as is well known, at Gay Head and the neighboring parts of Marthas Vineyard, and outcroppings of it are met with along the shores at various points within the region. In the course of the dredging clay was brought up in Vineyard Sound near the island of Cuttyhunk. Most of the mud, however, is composed in considerable part of organic matter. It is dark in color, and frequently has an offensive smell. It may be either sticky or semifluid or it may contain enough sand to alter the texture visibly. According as the mud or sand seemed to predominate in such a mixture, it was listed as "sandy mud" or "muddy sand." Sometimes such mixtures were called "sand and mud;" and in all probability the sand was at times overlooked, and the deposit was listed merely as "mud." Indeed, it is likely that almost any sample of mud, however pure in appearance, would be found upon careful sifting or decanting to contain a certain percentage of sand, and sometimes small amounts of fine gravel or shell fragments.

It had been our expectation to include in another chapter of this work the results of petrological and chemical analyses of the various bottom deposits, undertaken by Prof. Gilbert Van Ingen, of Princeton University. Thus far, however, Prof. Van Ingen has failed to complete his report upon these deposits, and its publication must therefore be deferred. The specimens upon which these analyses have been based were collected in 1905 during the third series of dredgings by the *Fish Hawk* in Vineyard Sound and in the course of some supplementary dredging, during the following summer, in Buzzards Bay. Satisfactory bottom samples from the earlier dredgings had not been preserved. In the present instance they were obtained exclusively by the use of a canvas bag, which prevented the washing out of the finer constituents. The larger ingredients, such as stones and large shells, were not, however, included in these samples preserved, so that

such analyses, while highly valuable as studies in mineralogy, would not alone give a fair idea of the respective bottom areas considered as the habitats of living beings.

The chart showing bottom characters represents rather crudely the condition of the floor of Buzzards Bay and Vineyard Sound, certain conventional modes of shading being adopted to represent the chief ingredients. The circles having a composite shading are commonly divided into equal halves or thirds, as if the various constituents were present in equal amounts. This results from the imperfections, in this regard, of the records upon which this chart is based. In the plotting of these circles, likewise, it has been necessary to adjust the position of each to that of its neighbors, with the result that in certain cases the symbol is removed some distance from the bottom designated. This is particularly true of the adlittoral (*Phalarope* and *Blue Wing*) stations.

Excluding a more or less narrow adlittoral zone, the bottom area here portrayed divides itself into three main regions: [a]

(1) Vineyard Sound, from its eastern end to a transverse line of division passing at a level somewhere between Tarpaulin Cove and Robinsons Hole. Here the predominant feature is the presence of gravel and stones. This area, it is true, contains one extensive shoal of sand, the so-called Middle Ground, and many other sandy areas. In the bays mud likewise occurs.

(2) Vineyard Sound from the line above referred to to its western end. Here the bottom is predominantly sandy, though gravel, stones, and mud occur in places. The presence of shell beds does not, of course, exclude the occurrence of an underlying bottom of sand.

(3) Buzzards Bay as a whole. Here mud predominates, except close to the eastern shore, and at the extreme lower end. The latter might be regarded as an independent area, but it seems scarcely large enough to warrant this.

The inshore (adlittoral) dredgings reveal in many cases a distinctly different type of bottom from that of the adjacent deeper waters; and various restricted areas of one or another kind of bottom may be found almost anywhere.

Owing to the methods employed, it is evident that the correlation of bottom characters with the distribution of species can be indicated with only rough approximation. During a given haul the dredge passes over a considerable stretch of sea floor and may collect samples of several totally different sorts of material. Organisms may likewise be collected from all points in this path. To determine by such means the kind of bottom proper to every species encountered is obviously impossible. A species may appear in the records as coming from "sand," whereas it may have been scraped from the surface of large stones at any point during the haul. Only the broader correspondence between the larger areas in which certain types of bottom predominate, and the general distribution of the species in question, is commonly to be regarded as significant. Again, when certain organisms are listed from certain types of bottom, the inference must not always be drawn that such bottoms themselves constitute its true habitat. Thus encrusting Bryozoa, which occurs upon shells, or algæ, are frequently listed from bottoms of sand or even mud.

[a] These divisions do not correspond to those recognized in the botanical section of this report. Of the latter there are five.

3. CURRENTS AND TIDES.

The first currents which concern us are two of the great permanent streams which maintain the circulation of the ocean, namely, the Gulf Stream and the southwardly flowing Labrador Current. Off the Massachusetts coast, the Gulf Stream is first encountered at a distance of about 85 nautical miles south of Marthas Vineyard and Nantucket; that is, just beyond the edge of the continental shelf. Its distance from shore varies from year to year, and even during lesser periods. It has been shown by Libbey (1895) that the Gulf Stream, during this part of its course, at least, presents by no means a regular outline in crosssection, but exhibits, on its coastal side, a wall having very roughly the contour of an inverted S. Its lower boundary, which Libbey identifies approximately with the 50° (F.) curve, sends a projection coastward between the adjacent colder zone and the bottom, while at a higher level the cold stratum referred to projects seaward into the midst of the warmer water of the Gulf Stream. (See Libbey's fig. 1–21.) This brings about the result that throughout a narrow strip along the continental declivity the latter is bathed by warmer water than it would otherwise be exposed to, and consequently supports a different fauna.

A not wholly convincing illustration of the dependence of the fauna of this section of the ocean upon the chance relations of these temperature zones is offered by the case of the well-known tilefish, which suddenly disappeared from the edge of the continental platform for a period of about 10 years. (See Collins, 1884; Verrill, 1884; Libbey, 1895; Bumpus, 1899.) Its extermination was first revealed by the presence, during the spring of 1882, of enormous numbers of the dead fishes floating upon the surface of the sea throughout a belt parallel to the coast and about 170 miles in length. At the same time Verrill (1884, p. 656) reported the "scarcity or absence of many of the species, especially of Crustacea, that were taken in the two previous years, in essentially the same localities and depths in vast numbers—several thousand at a time." Verrill accounted for this wholesale destruction of life by the occurrence of a heavy storm, which he believed to have "forced outward the very cold water that, even in summer, occupies the wide area of shallower sea, in less than 60 fathoms, along the coast, and thus caused a sudden lowering of the temperature along this narrow, comparatively warm zone, where the tilefish and the Crustacea referred to were formerly found." Libbey has endeavored to correlate the reappearance of the tilefish, about 1892, with a change in the position of the 50° curve; and, indeed, the first successful search for the fish after the catastrophe of 1882 was suggested by the discovery of changed temperature conditions.

But the influence of the Gulf Stream extends much nearer to the coast than the edge of the continental shelf, and without doubt affects our local faunal conditions. The presence nearly every year in Vineyard Sound of considerable masses of the *Sargassum bacciferum*, with its attendant fauna, shows that strong southerly winds may drive the surface water of the Gulf Stream as far as the mainland of Massachusetts.[a] And, apart from these occasional and obvious effects, it is probable that the warm current exerts a constant influence upon the coastal waters of southern New England, the two undergoing a certain degree of intermingling as a result of winds and tides. Indirectly,

[a] The prevailing wind during the summer months blows from the southwest quadrant. From records kept for five years on the Vineyard Sound Lightship (Rathbun, 1887), southwesterly winds are found to be the most frequent ones during the months of April to September, inclusive. At Nantucket, also, according to the report of the Chief of the Weather Bureau for 1909–10, the prevailing direction of the wind from May to September, inclusive, is southwest.

also, through its influence upon the atmosphere, the Gulf Stream must have a very pronounced effect in tempering the climate of this section of the coast, and this without doubt reacts upon the local sea areas.

As regards the presence of a definite southward-flowing cold current on the New England coast, there seem to be decided differences of opinion. According to the prevailing view, the Polar or Labrador Current may be detected along practically the entire Atlantic coast of the United States. A concise statement of this view has been furnished us by the Navy Department:

A cold current originating in high northern latitudes flows down past Labrador and Newfoundland, after which a portion trends away toward the southward over the Grand Banks, past Nova Scotia, and on southward in a narrowing belt as far even as the coast of Florida. From Sable Island to Florida its course is in general parallel to the Gulf Stream, near which it presents the frequent phenomenon of cold water welling up from below. In the shallower waters of the coast this colder current gives way to tidal influences which prevail to seaward over a wide area east of Nova Scotia, throughout the entire Gulf of Maine, and over Georges Bank and Nantucket Shoals.

Similar views are embodied in a number of different publications of the Hydrographic Office and Coast Survey and in certain Government charts. (E. g., Current Chart of the North Atlantic Ocean, No. 1308, pub. 1892.) They appear likewise in various popular accounts and atlases. (See Boguslawski, 1884, p. 269–272; Boguslawski and Krummel, 1887, p. 436, 437.) This assumption of a continuation of the Labrador Current along the southern shore of New England was made by Libbey, who thus interpreted the temperature relations which he observed there. Indeed, Libbey believed that the line between the two currents could often be seen from the deck of a vessel. (Libbey, 1891a, p. 236.) Various biologists also, including Packard and Verrill, have invoked the aid of this northern current in endeavoring to explain certain phenomena of geographical distribution. Verrill (1871, p. 258), indeed, believed that he found evidences of an offshoot of the Labrador Current extending for some distance into Long Island Sound.

According to another view of the case, the Labrador Current can not be traced farther south than Newfoundland, along the American coast, and has no connection with the "cold wall" or belt of cooler water lying between the Gulf Stream and the shores of the United States. It is held by Schott (1897, p. 204–208; see also Supan, 1903, p. 295) that such southward-flowing cold water as is found along the New England coast comes mainly from the Gulf of St. Lawrence; that the extent of this flow is but slight, and that the presence of the "cold wall" is largely a contrast phenomenon, due to the presence of the warmer Gulf Stream beyond.

Whether or not there occurs along the southern coast of New England a definite cold current of any considerable velocity, and, if so, whether this current is a continuation of the Labrador Stream, are matters of subordinate importance for our understanding of the biology of this region. The undisputed facts in the case seem to be that there is a belt of relatively cold water lying between the Gulf Stream and the New England shores, and that in summer this belt has a temperature very much lower than that of the waters immediately skirting the coast, particularly those of the partially inclosed bays and sounds, with whose fauna we have at present to deal. There is evidence, also, that north of Cape Cod this cold belt reaches the shores of the mainland itself and directly influences the littoral fauna; while south of Cape Cod it lies at some distance from the mainland, though its presence is felt upon the outlying shores of Marthas Vineyard and Nantucket. Referring to the temperature charts for the northwestern

Atlantic (charts 220, 221, 222), it will be seen that during the months of June to September, inclusive, the waters of Long Island Sound and those at the station just south of Buzzards Bay have a temperature several degrees higher than that of the first two stations to the eastward of these points. Farther yet to the eastward, however, the temperature again rapidly rises, owing to the presence of the Gulf Stream. The local relations will be discussed more fully in the next section of this chapter.

In addition to these great ocean streams, the local currents due to tides are very important in determining the fauna and flora of our waters. Tidal currents of sufficient velocity to be reckoned with by mariners occur at considerable distances offshore and, when deflected and concentrated by features of the coast line or by shoals, their velocity may be very great. In Woods Hole Passage, for example, they attain the speed of 8 miles per hour at spring tide. Such rapidly flowing currents, where the water is shallow and the bottom rocky, must result in a very high degree of oxygenation of the water. Moreover, a rapid current, of course, bears a more abundant food supply to those fixed or slow-moving organisms which depend for their food upon minute particles brought to them passively, or, as is the case with plants, upon gases or other substances in solution. Accordingly, we find beds of mussels and luxurious growths of anemones, ascidians, hydrozoa, bryozoa, and algæ in some of these tidal streams. On the other hand, tidal and other currents undoubtedly have a deleterious influence upon certain other organisms, which, through their agency, may become buried in sand or mud.

But the most widely prevailing effect of the tides locally is the continual mixing of the warmer (in summer), less dense, and relatively impure water of the coast line with the unlimited reservoir of cooler and purer water offshore. An idea of the magnitude of this process may be gained by considering the rate of tide flow in Vineyard Sound. This is as high as 2.6 knots per hour in the middle of the channel at the time of maximum velocity of the current. It is stated that "an object set adrift at the time of slack before flood will be carried 7 sea miles eastward before the reversal of the current, and an object set adrift at the time of slack before ebb will be carried 9 sea miles westward before the beginning of the flood stream."[a] Thus a certain part of the water at least travels a distance of one-half or more of the length of Vineyard Sound during a single phase of the tide. Owing to the retardation due to the friction of the shores and bottom, the mean sectional velocity would perhaps not exceed half the figures stated above. Even so, however, the water throughout the entire section would be displaced on the average to the extent of 3½ nautical miles during the flood phase and to the extent of 4½ miles during the ebb.

There would thus be a net westerly movement of the water amounting to about 1 knot during each complete tidal cycle, or about 2 knots in 24 hours. Were this the only factor concerned, it would thus require about eight days to completely replace the water of Vineyard Sound. In reality the ocean water brought in during the flood tide constantly mixes with that already present in the Sound, and this process of diffusion must result in a fairly rapid renewal of the latter, quite independently of the transfer of water resulting from the predominance of the westerly current. It seems likely, therefore, that a week would much more than suffice to bring about a practically complete change of water in Vineyard Sound. Obviously, the conditions are much less simple in reality

[a] These data, though not the deductions which have been drawn from them, were furnished by the office of the Coast and Geodetic Survey. See also current diagram for Nantucket and Vineyard Sounds, in U. S. Coast Pilot, Atlantic Coast, pt. III, p. 152.

than is implied in such a computation, for the rate of renewal is very different in different parts of the Sound. The more central portion of the stream would enter to a much greater distance than that close to shore, while the waters contained in various depressions of the bottom (if we may judge from temperature considerations) are probably renewed at a comparatively slow rate.

In Buzzards Bay the change is in all probability much more slow, owing to the fact that this body of water communicates with the ocean at one end only, and that its mouth is very narrow in proportion to the total area of the Bay. Here there plainly can be no such continuous displacement in one direction as was found to occur in Vineyard Sound, and the renewal must be effected entirely through the mixture of waters resulting from the ebb and flow of the tide. The amplitude of the tides is, however, considerably greater in the Bay than in the Sound. Since the mean depth of the former is much less than that of the latter, a proportionally larger degree of change must result from this cause. The mean depth of Buzzards Bay, as computed from the 91 soundings indicated upon the chart contained in the Atlantic Coast Pilot, part III, is a little over 41 feet. The average rise and fall of the tide in Buzzards Bay is about 4 feet. Thus the amount of water brought in by the flood tide is equal to about one-tenth of the total volume already contained in the Bay. To what degree this ocean water mixes with that already present in the Bay, and, conversely, what proportion of the water which leaves the Bay on the ebb tide consists of that which entered on the previous flood, would be impossible to determine even approximately. Assuming that as much as one-half of this remains behind, which seems an extreme supposition, then the entire Bay would require 20 tides or 10 days to effect a complete renewal. On the whole, therefore, it seems likely that the average rate at which the water is renewed in Buzzards Bay is not over half that which obtains in Vineyard Sound.

It is obvious, however, that this renewal of water would take place at quite different rates in different parts of the Bay. Near the mouth the change is probably much more rapid than the above figures would imply, while at its head the renewal of water is probably far slower. Likewise the surface water is probably changed at a much more rapid rate than are the lower strata. It must be remembered, also, that it is not pure ocean water which enters either the Bay or the Sound, but coastal water, which has been contaminated during previous ebb tides. Nevertheless, even such crude estimates may be of service in showing the relative stagnancy of the two bodies of water under consideration.

A feature of great importance in determining the character of the local littoral fauna and flora is the slight amplitude of the tides throughout the entire region. A table will best illustrate the amplitude of the mean, spring, and neap tides at 11 representative points.

	Mean.	Spring.	Neap.		Mean.	Spring.	Neap.
	Feet.	*Feet.*	*Feet.*		*Feet.*	*Feet.*	*Feet.*
Wareham	4.1	5.1	3.0	Tarpaulin Cove	2.3	2.8	1.7
New Bedford	4.2	5.2	3.1	Vineyard Haven	1.7	2.1	1.2
Woods Hole (Bay side)	4.1	5.0	3.0	Woods Hole (Sound side)	1.7	2.1	1.2
Mouth of Bay (Westport)	3.1	3.8	2.3	Edgartown	2.0	2.4	1.5
Cuttyhunk	3.5	4.3	2.6	Nantucket Harbor	3.1	3.8	2.3
Gay Head	3.0	3.7	2.2				

The resulting narrowness of the littoral (intertidal) zone is a characteristic feature of the region, and stands in decided contrast to the conditions encountered on the Maine coast, where the average tidal range is not less than 10 feet.

4. TEMPERATURE.

The surface and bottom temperatures were recorded for each of the regular dredging stations of the *Fish Hawk* and were entered in the original records for these. It became evident, however, that the methods then employed were not sufficiently accurate for purposes of careful comparison; likewise that the temperature determinations should be taken as nearly simultaneously as possible throughout the entire area under consideration. Accordingly, new observations were made at four different seasons of the year, with standardized instruments and in accordance with more precise methods. Density determinations were made at the same time as those upon temperature, but a discussion of these will be deferred till the following section.

The methods pursued in making the temperature observations were as follows: Certain stations were selected which were believed to be representative of all sorts of conditions as to geographical position, depth, tidal influences, etc. These were commonly selected from among the regular dredging stations plotted upon the distribution charts, but they were not located by the vessel with any close approach to accuracy. In a few cases, however, other points were chosen, so that it was thought best to give a new set of numbers, or rather letters, to the temperature stations. They ranged from A to Y in the Sound and from A to V in the Bay.[a] (See chart 211.) In taking the August series of temperatures the *Fish Hawk* was employed; in November and June the *Phalarope* was used; in March the *Blue Wing*. The bottom temperatures were obtained with Negretti-Zambra thermometers, provided with the Tanner inverting case (Tanner, 1884, p. 26); and the instrument was in all cases left at the bottom for a period of 10 minutes. Our own and previous tests (see Kidder, 1887, p. 203) have shown that reliable results can not be obtained in less time. The thermometer was then upset by a "messenger," rendering impossible any further change in the column of mercury, except the slight expansion or contraction of the thread itself, which could be allowed for whenever the water and air temperature differed sufficiently. The surface temperature was taken by means of an ordinary thermometer of the Queen or Tagliabue make, having a long scale. Surface water was drawn in a dip bucket and kept in the shade while the thermometer was in use. When air and water temperature differed much, the pail of water was changed at least once before the final reading was made. The air temperature was likewise recorded, though this was far from exact, owing to the artificial sources of heat necessarily present on a steam vessel.

August series.—The first series of temperature determinations was made between August 14 and 29, 1907. Twenty-five observations in Vineyard Sound were made on August 14, 15, and 16. The order followed was such that stations scattered throughout nearly the whole length of the Sound were visited on the same day. Thus, differences due to locality would not be confused with differences due to meteorological changes. Buzzards Bay was then covered on August 19 and 20, most of the stations being reached on the first day. Certain stations in Vineyard Sound were also revisited

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[a] Not all of these stations were included in every series of observations, while the greater number of the Bay stations were omitted from the March series.

on August 20, as likewise on August 22; and stations in both Vineyard Sound and Buzzards Bay were visited for a second, third, and even fourth time on August 28 and 29. Thus, while it is not possible to present simultaneous readings throughout all the waters under consideration, the most extreme points were reached within a limit of five days (August 14–19); and such supplementary determinations were made as to eliminate confusion of results by seasonal change. A consideration of these supplementary temperature determinations, 41 in number, shows that, although they were made after an average interval of nine days, the mean difference (irrespective of sign) between the first and the later determination was 1.8° F. It will be noted also that in many cases the later temperature was higher, instead of lower, though, on the average, it was found to be about $\frac{3}{10}$ degree lower. Moreover, a consideration of the chart (No. 219) representing the mean annual temperature curves for the Woods Hole station shows that the variation in water temperature at the latter point during the entire period of the present observations (August 14–29) is, in this five-year average, but a trifle over 1° F. The variations within the limits of a single day, due to tidal influences, are doubtless more serious sources of error, at least for surface temperatures; but it was, of course, impossible to eliminate these.

TABLE 1.—TEMPERATURE AND DENSITY: VINEYARD SOUND, AUGUST, 1907.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
A	Aug. 16	9½	67.3	68.6	1.0239	68.8	1.0239
B	...do....	4½	67.7	68.3	1.0238	68.1	1.0239
C	...do....	7	68.3	67.6	1.0241	67.4	1.0237
D	...do....	11¼	67.7	66.8	1.0237	66.3	1.0242
E	Aug. 14	5	....	....	1.0238	69.3	1.0241
F	...do....	10½	66.3	....	1.0239	68.5	1.0237
G	Aug. 15	10	67.3	67.3	1.0241	66.9	1.0241
G (repeated)	Aug. 22	11	67.0	66.4	1.0237	66.3	1.0237
H	Aug. 16	9½	67.8	65.8	1.0242	65.3	1.0240
I	Aug. 14	9½	66.7	....	1.0235	67.5	1.0239
I (repeated)	Aug. 22	10¼	67.8	67.3	1.0234	65.5	1.0236
J	Aug. 15	10	68.3	67.3	1.0240	67.4	1.0239
J (repeated)	Aug. 22	10½	67.3	64.6	1.0236	63.4	1.0236
K	Aug. 16	9	68.3	66.3	1.0239	65.3	1.0239
L	Aug. 14	12¾	67.8	66.8	1.0240	65.5	1.0240
L (repeated)	Aug. 22	16	67.6	65.6	1.0237	62.4	1.0236
M	Aug. 15	6½	70.3	62.8	1.0243	61.4	1.0243
N	...do....	12¾	69.3	65.3	1.0241	61.1	1.0239
N (repeated)	Aug. 22	....	68.3	64.3	1.0238	60.3	1.0237
O	Aug. 14	9	67.1	65.8	1.0238	63.5	1.0241
P	Aug. 16	10	66.8	64.8	1.0239	60.9	1.0241
P (repeated)	Aug. 22	12¾	66.2	61.9	1.0237	58.2	1.0237
P (repeated)	Aug. 28	13½	70.3	63.7	1.0235	61.4	1.0238
Q	Aug. 15	8½	69.8	63.8	1.0243	59.3	1.0243
R	Aug. 14	10	69.1	69.3	1.0238	61.4	1.0239
S	...do....	10	68.7	62.8	1.0237	58.6	1.0241
T	Aug. 16	14½	64.5	63.0	1.0240	58.8	1.0239
U	...do....	11¾	64.9	62.4	1.0242	59.2	1.0236
U (repeated)	Aug. 22	11	71.8	63.3	1.0237	61.7	1.0237
U (repeated)	Aug. 28	11½	70.3	62.3	1.0235	61.2	1.0234
V	Aug. 16	10½	64.2	63.1	1.0241	60.1	1.0241

TABLE 1.—TEMPERATURE AND DENSITY: VINEYARD SOUND, AUGUST, 1907—Continued.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
V (repeated)	Aug. 20	9¾	69.7	64.3	1.0233	61.2	1.0236
V (repeated)	Aug. 28	7½	68.3	64.3	1.0240	60.2	1.0238
V (repeated)	Aug. 29	9¾	64.3	63.1	1.0240	58.2	1.0239
W	Aug. 16	17¾	64.3	60.3	1.0241	55.0	1.0241
W (repeated)	Aug. 20	17¾	72.3	64.3	1.0234	59.0	1.0237
W (repeated)	Aug. 28	17	71.8	63.9	1.0239	59.9	1.0241
W (repeated)	Aug. 29	14½	63.8	61.5	1.0240	57.2	1.0242
X	Aug. 16	12½	64.6	63.8	1.0241	57.2	1.0241
X (repeated)	Aug. 28	16¾	69.3	62.5	1.0234	53.2	1.0239
Y	Aug. 16	8	63.8	63.3	1.0240	61.3	1.0239
Mean			67.68	64.70	1.02385	62.28	1.02389

TABLE 2.—TEMPERATURE AND DENSITY: BUZZARDS BAY, AUGUST, 1907.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
A	Aug. 19	3½	65.1	71.3	1.0226	71.3	1.0224
B	...do.....	3½	66.3	71.5	1.0229	71.0	1.0231
C	...do.....	5	64.3	70.3	1.0229	70.7	1.0232
D	...do.....	4	66.3	71.1	1.0233	70.2	1.0234
E	...do.....	5¼	67.3	70.3	1.0235	70.4	1.0234
F	...do.....	5½	62.8	69.5	1.0234	69.3	1.0235
G	...do.....	5¼	71.3	69.8	1.0236	68.3	1.0238
H	...do.....	9½	69.9	70.5	1.0234	66.0	1.0236
I	Aug. 20	6¾	66.5	69.3	1.0240	68.4	1.0235
J	Aug. 19	5	69.5	69.8	1.0237	68.3	1.0236
K	...do.....	8	66.3	69.8	1.0234	65.0	1.0234
L	Aug. 20	9	66.8	67.6	1.0232	64.6	1.0236
L (repeated)	Aug. 29	9½	65.2	65.2	1.0237	64.3	1.0238
M	Aug. 20	7½	67.9	68.8	1.0233	67.6	1.0237
N	...do.....	6¾	67.9	66.9	1.0235	65.3	1.0236
O	Aug. 19	7	66.6	67.8	1.0237	67.1	1.0236
P	Aug. 20	10	67.8	66.8	1.0234	64.2	1.0236
P (repeated)	Aug. 29	8	65.3	65.0	1.0235	64.3	1.0237
Q	Aug. 19	8½	66.1	67.3	1.0235	64.1	1.0235
R	Aug. 20	6¾	71.3	67.3	1.0235	66.6	1.0234
R (repeated)	Aug. 29	6¼	66.5	65.4	1.0235	64.7	1.0237
S	Aug. 20	12	74.8	67.8	1.0233	63.2	1.0236
T	...do.....	6¾	72.4	65.8	1.0233	63.2	1.0233
U	...do.....	9½	68.9	66.9	1.0236	64.3	1.0233
U (repeated)	Aug. 29	10	64.7	64.8	1.0238	64.0	1.0239
V	Aug. 20	12¾	72.3	64.8	1.0234	60.2	1.0236
V (repeated)	Aug. 29	9	64.1	62.7	1.0241	60.6	1.0237
Mean			67.56	67.93	1.02344	66.19	1.02350

Tables 1 and 2 show the temperature[a] and density conditions encountered during the August observations. Chart 211 represents the surface and bottom temperatures for each station, the figure used being in each case the earliest one taken. The following generalized statements may be made regarding these figures:

(1) The greatest extremes of temperature recorded are 71.5° and 55.0°, giving a range of 16.5° within the limits of the region.

(2) The surface temperatures average 2.21° higher than the bottom temperatures, the differences increasing as we pass toward the western end of Vineyard Sound and the lower end of Buzzards Bay. The mean figures (based upon all the figures of the tables) are surface 66.04°, and bottom 63.83°.

(3) Buzzards Bay contains warmer water than Vineyard Sound, the mean figures being 67.93° (surface) and 66.19° (bottom) for the Bay, and 64.70° (surface) and 62.28° (bottom) for the Sound.

(4) In both Vineyard Sound and Buzzards Bay, both at the surface and the bottom, there is a steady decrease in temperature as we pass from northeast to southwest; i. e., toward the open ocean.

In Buzzards Bay the maximum surface temperature (71.5°) was found near the head, while the minimum (64.8°) occurred off Cuttyhunk. The maximum bottom temperature also occurred at the head of the Bay, where surface and bottom waters were practically of equal warmth. A minimum of 60.2° was found off Cuttyhunk, just at the mouth of the Bay.

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[a] We have very reluctantly decided to employ the Fahrenheit scale in the present work, for the following reasons: Our instruments, and practically all those in use by the Bureau of Fisheries, are graduated in this scale. Moreover, in past American hydrographic work temperatures have usually, if not always, been expressed in Fahrenheit degrees. We should, however, have employed the centigrade scale, despite the foregoing considerations, were it not for the fact that our temperature charts were drawn before due consideration was given to this matter; and it does not seem worth while to change them now, particularly as plates have already been prepared from some of them. For the convenience of those who are more familiar with the centigrade scale we append a conversion table:

TABLE FOR CONVERSION OF FAHRENHEIT TO CENTIGRADE DEGREES.

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
°	°	°	°	°	°	°	°	°	°
+80	+26.67	+69	+20.56	+58	+14.44	+47	+8.33	+37	+2.78
79	26.11	68	20.00	57	13.89	46	7.78	36	2.22
78	25.56	67	19.44	56	13.33	45	7.22	35	1.67
77	25.00	66	18.89	55	12.78	44	6.67	34	1.11
76	24.44	65	18.33	54	12.22	43	6.11	33	0.56
75	23.89	64	17.78	53	11.67	42	5.56	32	0.00
74	23.33	63	17.22	52	11.11	41	5.00	31	−0.56
73	22.78	62	16.67	51	10.56	40	4.44	30	−1.11
72	22.22	61	16.11	50	10.00	39	3.89	29	−1.67
71	21.67	60	15.56	49	9.44	38	3.33	28	−2.22
70	21.11	59	15.00	48	8.89				

In Vineyard Sound, the maximum surface temperature (69.3°) occurred near Nashawena Island, but such a temperature was quite exceptional in this portion of the Sound, as reference to the chart will show at a glance. With this exception, the highest temperatures are at the eastern end. At one station just beyond the western limits of Vineyard Sound (W) the surface and bottom figures were 60.3° and 55.0°, respectively. A rather abrupt fall in temperature is encountered in passing southwestward through the Sound when we reach the line passing from Robinson Hole to Kopeecon Point. The mean bottom temperatures for the portions of the Sound lying above and below this line are 67.35° and 60 24°, respectively (based upon chart figures only). As we shall find later, this lower temperature of the outer portion of the Sound is correlated with important differences in the bottom fauna. In Buzzards Bay the lowering of temperature toward the mouth is less abrupt, and water colder than 64° occurs only near the extreme end. The water appears to be at no point as cold as it is on the other side of the Elizabeth Islands.

TABLE 3.—TEMPERATURE AND DENSITY: VINEYARD SOUND, NOVEMBER, 1907.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
C	Nov. 12	8	39.0	50.2	1.0240	51.1	1.0242
D[2]	Nov. 11	11½	47.0	51.4	1.0237	51.6	1.0241
E	...do	6	46.0	51.2	1.0238	51.4	1.0241
F	...do	15	48.0	51.7	1.0238	51.4	1.0238
G	Nov. 12	10	40.0	49.7	1.0240	51.5	1.0241
G (repeated)	Nov. 15	11½	37.5	49.7	1.0240	50.3	1.0240
H	Nov. 12	7	39.0	50.7	1.0242	50.8	1.0242
I	Nov. 11	12	49.0	51.2	1.0238	51.4	1.0238
J	Nov. 12	10	39.5	51.1	1.0242	51.5	1.0241
K	...do	13	40.5	50.6	1.0240	....	1.0241
L	Nov. 11	5	49.0	51.2	1.0238	51.4	1.0238
M	Nov. 12	7	40.5	51.1	1.0240	51.8	1.0240
M (repeated)	Nov. 15	7	39.0	49.7	1.0240	50.5	1.0240
N	Nov. 12	11½	39.0	51.1	1.0241	51.5	1.0241
O	Nov. 11	8	49.0	51.2	1.0238	50.9	1.0238
P	Nov. 12	12?	42.0	51.2	1.0241	52.0	1.0241
Q	...do	8¾	41.0	50.7	1.0242	50.5	1.0240
S	Nov. 11	8	49.0	51.7	1.0238	51.1	1.0241
T	Nov. 12	14	42.0	51.7	1.0242	52.0	1.0241
U	...do	10½	41.0	50.7	1.0241	51.9	1.0243
V	...do	8	43.0	51.2	1.0241	51.9	1.0238
W	...do	18	45.0	51.2	1.0243	52.0	1.0241
W (repeated)	Nov. 15	17½	40.0	50.1	1.0240	51.6	1.0241
X	Nov. 12	11½	39.5	51.2	1.0241	52.5	1.0244
Y	...do	8½	41.5	50.9	1.0241	52.0	1.0242
Mean			42.64	50.90	1.02401	51.44	1.02406

TABLE 4.—TEMPERATURE AND DENSITY: BUZZARDS BAY, NOVEMBER, 1907.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
A	Nov. 13	3	35.0	46.3	1.0214	49.8	1.0220
B	...do.....	2½	37.0	47.7	1.0228	49.4	1.0229
C	...do.....	6	34.0	48.2	1.0228	50.1	1.0229
D	...do.....	4½	43.0	48.2	1.0230	49.5	1.0230
E	...do.....	6½	36.0	47.3	1.0226	50.0	1.0228
F	...do.....	5½	35.0	48.5	1.0231	49.1	1.0232
G	...do.....	5	39.0	48.7	1.0236	49.3	1.0236
H	...do.....	8½	41.0	48.7	1.0237	49.8	1.0237
I	...do.....	6	33.0	49.2	1.0235	49.8	1.0238
J	...do.....	5	41.5	48.2	1.0234	48.9	1.0233
K	...do.....	7	42.0	49.7	1.0237	50.5	1.0237
L	...do.....	8½	43.0	49.5	1.0237	50.1	1.0237
M	Nov. 15	6	38.0	47.2	1.0238	47.5	1.0237
N	...do.....	6½	35.5	48.0	1.0238	48.5	1.0239
O	...do.....	5	35.5	48.5	1.0238	48.8	1.0238
P	...do.....	8	36.0	48.6	1.0239	50.0	1.0240
Q	...do.....	5½	36.0	48.7	1.0238	49.1	1.0239
R	...do.....	6½	39.0	47.9	1.0236	49.1	1.0236
S	...do.....	15	40.0	49.7	1.0237	50.5	1.0237
T	...do.....	6½	39.0	49.7	1.0240	50.1	1.0240
U	...do.....	7	43.0	48.7	1.0236	49.0	1.0236
V	...do.....	17	40.0	49.7	1.0240	50.4	1.0240
Mean	....	....	38.25	48.50	1.02342	49.51	1.02349

November.—Temperature and density conditions at the middle of November, 1907, are shown in tables 3 and 4, the temperature conditions being shown on chart 212. When compared with the conditions during August, the chief facts to be noted are:

(1) The great reduction in water temperature naturally resulting from the approach of winter. The mean of all the figures is 50.14° as against 64.91° during the August observations.

(2) The comparative uniformity of all the figures, the extremes being 46.3° and 52.5°, showing a range of 6.2°, in place of a range of 16.5° as in August.

(3) The exact reversal of the differences found in August. Here the surface temperatures are somewhat *lower* than the bottom ones (average=49.78° and 50.47° respectively); the Bay is *colder* than the Sound (average=49.00° and 51.16°); and we meet with slightly *higher* temperatures as we pass toward the open ocean. This last tendency is not very evident in Vineyard Sound, but is quite marked in Buzzards Bay. All these differences are, of course, quite intelligible. At this time of the year the air temperature has become much colder than that of the water. It is natural, therefore, that the surface of the sea should cool more rapidly than the bottom, and that the shallower, more sheltered waters should cool more rapidly than the open ocean.

TABLE 5.—TEMPERATURE AND DENSITY, VINEYARD SOUND, MARCH, 1908.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
E	Mar. 20	5½	31.5	36.9	1.0236	36.8	1.0233
I	...do.....	13	29.5	36.2	1.0232	37.6	1.0234
I (repeated)	Mar. 21	11	33.0	36.4	1.0235	36.5	1.0235
J	Mar. 20	11½	28.5	36.3	1.0233	36.3	1.0235
K	...do.....	8	32.5	36.9	1.0237	36.7	1.0237
O	...do.....	7	30.0	36.3	1.0232	36.2	1.0233
P	...do.....	14	30.0	37.0	1.0238	36.6	1.0238
Q	...do.....	10½	32.0	37.1	1.0237	36.6	1.0240
S	...do.....	7	31.0	36.6	1.0236	36.5	1.0236
U	...do.....	8	31.5	36.8	1.0238	36.6	1.0239
V	...do.....	5	28.0	36.5	....	36.6	....
W	...do.....	18	33.0	36.7	1.0238	37.4	1.0238
Mean	....	....	30.87	36.64	1.02356	36.70	1.02361

TABLE 6.—TEMPERATURE AND DENSITY, BUZZARDS BAY, MARCH, 1908.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
A	Mar. 21	2½	28.0	37.1	1.0212	37.6	1.0224
D	...do.....	4	30.5	37.4	1.0222	36.6	1.0225
E	...do.....	5½	28.0	36.8	1.0222	37.1	1.0234
F	...do.....	4½	29.0	36.2	1.0226	36.1	1.0227
H	...do.....	9	31.0	37.0	1.0226	36.5	1.0239
L	...do.....	8½	30.0	36.7	1.0229	36.3	1.0234
Mean	....	....	29.41	36.86	1.02228	36.70	1.02305

March.—Another set of determinations was made on March 20 and 21, 1908 (tables 5 and 6; chart 213). Owing to the inclemency of the weather and to the fact that only the *Blue Wing* was available for the work, a smaller number of soundings was made at this time, and indeed the lower part of Buzzards Bay was entirely neglected. The results are none the less interesting. The mean for the entire set of 36 determinations (including both surface and bottom) was 36.71°. A high degree of uniformity was manifest throughout the entire region, for the most extreme temperatures recorded were 36.1° and 37.6°, while the average deviation (i. e., the average departure from the average) was only 0.32°. Moreover, such slight differences as did occur seemed to bear no definite relation to locality.

TABLE 7.—TEMPERATURE AND DENSITY, VINEYARD SOUND, JUNE, 1908.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
E	June 5	5	56	58.4	1.0233	58.4	....
H	...do.....	7½	56	57.5	1.0234	57.4	1.0234
I	...do.....	12	63	58.0	1.0233	57.7	1.0231
J	...do.....	11	59	57.4	1.0234	58.3	1.0234
K	...do.....	11½	57	57.4	1.0233	56.7	1.0234
O	...do.....	8	59	57.2	1.0234	56.5	1.0233
P	...do.....	13	59	56.3	1.0234	56.0	1.0235
Q	...do.....	9	59	56.3	1.0233	55.4	1.0232
S	...do.....	9	59	56.8	1.0233	55.8	1.0235
U	...do.....	9	59	54.3	1.0234	49.8	1.0234
W	...do.....	18	57	55.3	1.0233	53.3	1.0233
X	...do.....	10	59	55.8	1.0243	47.9	1.0234
Y	...do.....	9	60	54.6	1.0234	53.0	1.0234
Mean			58.61	56.56	1.02342	55.09	1.02336

TABLE 8.—TEMPERATURE AND DENSITY, BUZZARDS BAY, JUNE, 1908.

Temperature station.	Date.	Depth in fathoms.	Air temperature.	Surface temperature.	Surface density (at 15°C.).	Bottom temperature.	Bottom density (at 15°C.).
A	June 6	4	60	64.0	1.0224	64.4	1.0223
D	...do.....	5	59	63.3	1.0223	62.8	1.0222
E	...do.....	6¾	64	62.2	1.0227	61.6	1.0227
F	...do.....	4¾	64	61.8	1.0227	60.3	1.0227
H	...do.....	8	61	59.5	1.0233	59.1	1.0229
I	...do.....	7½	56	56.1	1.0233	55.1	1.0234
J	...do.....	5	57	61.4	1.0229	60.8	1.0229
K	...do.....	8	59	59.7	1.0232	58.7	1.0231
L	...do.....	9	55	57.8	1.0232	59.0	1.0234
O	...do.....	5	56	61.3	1.0230	59.8	1.0232
P	...do.....	12½	58	59.3	1.0232	57.6	1.0233
Q	...do.....	6½	55	58.3	1.0235	57.9	1.0231
S	...do.....	12½	57	58.3	1.0232	56.7	1.0232
Mean			58.53	60.23	1.02299	59.52	1.02295

June.—On June 5 and 6, 1908, surface and bottom temperatures were determined at 26 stations in Vineyard Sound and Buzzards Bay (tables 7 and 8; chart 214). The mean of all these 52 figures is 57.85° F., or 7.06° lower than the mean for the August observations. The relations which were found to obtain during August are, however, manifested with equal clearness in the June series, the figures being:

Maximum	64.40
Minimum	47.90
Mean for Buzzards Bay	59.88
Mean for Vineyard Sound	55.83
Mean for surface	58.39
Mean for bottom	57.31

It is likewise plain that the temperatures decline noticeably as we pass toward the open ocean, the maximum temperature being found at the head of Buzzards Bay, the minimum at the mouth of Vineyard Sound. There was, however, at the time of the June observations, no abrupt fall of temperature beyond Robinsons Hole.

Annual temperature cycle.—Before discussing the probable significance of these observations upon the waters of Vineyard Sound and Buzzards Bay, mention must be made of the annual temperature cycle at Woods Hole.

TABLE 9.—AIR TEMPERATURE AT NOON: WOODS HOLE STATION.

Years.	January.			February.			March.			April.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	46	12	30.3	42	21	30.7	53	29	42.7	62	40	49.4
1903	46	10	32.5	52	10	34.6	55	33	44.9	65	36	50.3
1904	45	2	26.3	45	8	26.6	50	21	37.1	58	36	45.4
1905	47	14	29.1	41	12	27.0	54	24	37.9	57	37	47.7
1906	53	18	37.0	47	11	33.2	51	24	35.3	59	38	48.9
Five years	53	2	31.03	52	8	30.39	55	21	39.58	65	36	48.33

Years.	May.			June.			July.			August.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	66	49	57.6	71	58	65.9	80	65	71.4	78	64	71.9
1903	76	46	60.7	71	51	63.1	79	64	72.4	76	57	70.1
1904	68	54	60.5	76	54	66.1	83	68	74.0	79	65	72.4
1905	69	50	58.4	78	48	66.4	82	63	74.0	80	60	70.4
1906	67	45	58.9	81	55	68.5	80	65	70.0	82	67	75.0
Five years	76	45	59.21	81	48	66.02	83	63	72.35	82	57	71.95

Years.	September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	75	61	67.9	68	41	57.7	59	38	50.7	47	2	33.6
1903	78	54	67.6	68	40	57.8	60	25	43.6	50	16	32.5
1904	74	48	65.8	69	38	54.9	54	27	42.1	47	15	30.7
1905	71	51	66.1	69	45	57.7	59	28	44.9	55	25	39.0
1906	75.5	58	67.7	70	49	58.9	57	33	45.1	48	9	33.4
Five years	78	48	67.01	70	38	57.39	60	25	45.29	55	2	33.82

TABLE 10.—WATER TEMPERATURE AT NOON, WOODS HOLE STATION.

Years.	January.			February.			March.			April.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	34.5	29.5	31.7	31.5	[a]28.0	29.3	42.5	32.5	36.6	52.0	41.5	45.8
1903	36.5	29.5	33.0	35.0	30.0	32.4	44.0	34.0	39.6	50.5	44.0	46.6
1904	32.0	[a]28.0	29.5	29.5	28.5	29.1	39.0	29.5	33.8	45.5	36.5	41.3
1905	35.0	29.5	31.0	30.0	29.0	29.5	39.5	29.5	32.9	48.0	39.5	42.9
1906	39.5	33.5	36.5	37.0	33.0	34.7	38.0	32.5	35.2	48.0	37.0	42.7
Five years	39.5	[a]28.0	32.33	37.0	[a]28.0	31.00	44.0	29.5	35.64	52.0	36.5	43.90

Years.	May.			June.			July.			August.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	59.0	51.0	54.6	65.0	58.5	62.9	69.0	64.0	66.7	71.0	68.0	69.3
1903	61.0	50.0	59.0	62.5	59.0	61.3	70.5	63.0	67.9	69.5	63.0	67.7
1904	61.5	46.5	54.1	69.0	58.5	62.8	73.0	67.0	69.8	72.0	69.0	70.2
1905	59.0	47.0	52.8	66.5	57.5	62.0	74.0	66.0	70.4	73.0	67.5	70.0
1906	58.5	48.5	54.1	68.5	58.5	63.2	73.0	67.0	69.3	74.5	69.5	71.4
Five years	61.5	46.5	54.92	69.0	57.5	62.42	74.0	63.0	68.83	74.5	63.0	69.74

Years.	September.			October.			November.			December.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
1902	70.0	65.0	67.5	65.0	54.0	60.5	55.0	47.0	52.0	47.5	35.0	38.9
1903	69.0	63.5	66.6	64.0	51.5	59.2	53.5	38.5	47.9	40.0	32.0	36.6
1904	70.0	64.0	67.0	63.0	51.5	57.6	52.0	40.0	46.3	41.0	31.5	34.4
1905	69.0	63.0	66.4	64.0	54.0	59.6	54.5	44.0	48.2	44.5	38.0	40.0
1906	71.0	66.0	68.5	65.0	56.5	60.3	54.0	42.5	47.0	42.5	33.5	36.3
Five years	71.0	63.0	67.20	65.0	51.5	59.44	55.0	38.5	48.28	47.5	31.5	37.23

[a] Based doubtless upon an inexact observation, since this temperature is below the freezing point of sea water.

Curves showing seasonal variations in the air and water temperatures at the Woods Hole station for five years are presented on chart 219. These curves are based upon the noon temperatures contained in the station records from 1902 to 1906, inclusive.[b] The ordinate for each day is the mean of the five years' figures for that day. Such curves do not, of course, exhibit the extreme conditions, since maximum and minimum figures are neutralized in the process of averaging. The water temperatures are naturally those which chiefly concern us at present. It will be seen that the highest point in the curve showing these is at August 12, where the mean temperature is slightly over 71°. Reference to table 10 shows that the maximum temperature for August (and for the year) recorded during these five years is 74.5°. The lowest point in the curve is on February 19, where a mean temperature of 30° is almost reached. The minimum for the entire

[b] Cf. Edwards in First Report U. S. Fish Commission, with which these figures agree fairly closely.

period is about 28.5° F.,[a] which is the freezing point of sea water. This temperature is perhaps reached at one time or another nearly every winter.

An analysis of this curve reveals several other facts worthy of mention. (We omit as irrelevant the interesting relations between the curves for air and for water.) There are two comparatively level sections having a duration of about two months each, occurring in midwinter and midsummer, respectively. During each of these periods, the range of temperature is only about 3 degrees. The remainder of the year is made up of the long vernal ascent, and the somewhat more abrupt autumnal decline. During 131 days, or rather more than a third of the entire year (June 3 to Oct. 12), the temperature remains above 60°; from May 5 to November 8, the temperature exceeds 50°; while from April 3 to December 5, the curve is above the 40° line. On the other hand, from December 26 to March 14, the temperature of 35° is not exceeded.

The water here employed was that drawn from the surface at the local pier, close to the buildings of the station. This water rapidly changes with the tides which sweep through Woods Hole Passage, and therefore is not liable to the extreme fluctuations found in more inclosed areas. The figures doubtless represent fairly well the surface (and likewise the bottom) temperature of Woods Hole Harbor and of the adjacent shallower parts of Buzzards Bay and Vineyard Sound. The mean water temperature for this entire period of five years was 51.01° F.; the mean air temperature for the same period was 51.98°. Since these figures are based upon temperatures taken at noon, they are doubtless somewhat too high, though the error in the case of the water temperatures is probably slight.

It will be important for our future discussion to make a comparison of the water temperatures at Woods Hole and those at the United States Fisheries stations at Gloucester, Mass., and Boothbay, Me. For this purpose we have employed the records of only three years at each station, the same years (1905, 1906, 1907) being used in each case. Thus the figures here presented for Woods Hole necessarily differ somewhat from those given in the preceding table.

TABLE 11.—MEAN WATER TEMPERATURES (NOON) AT BOOTHBAY, GLOUCESTER, AND WOODS HOLE FOR THE YEARS 1905, 1906, 1907.[a]

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Boothbay	[b] 33.5	[b] 30.3	32.2	37.8	44.1	51.8	58.5	61.0	56.0	48.7	42.4	37.0
Gloucester	36.1	32.7	35.7	41.4	48.2	56.6	63.1	63.1	59.8	53.2	45.8	39.7
Woods Hole	33.9	31.2	33.6	42.1	51.9	61.3	69.4	70.4	67.4	59.1	48.1	38.7

[a] Based upon records furnished by the superintendents of these stations.
[b] Based on two years only (1906, 1907).

From the foregoing figures the following facts may be gathered:

(1) That the mean water temperature for these three years was highest at Woods Hole (50.59°), next highest at Gloucester (47.95°), and lowest at Boothbay (44.44°).

(2) That these differences are at a maximum during the summer months, being reduced to a minimum or even reversed during the winter months. Thus the annual range of temperature is greater as we pass to the southward.

[a] Stated as 28° in the table. This was doubtless due to an error in the reading.

(3) For every month of the year the water temperatures at Gloucester are higher than those at Boothbay. On the other hand, during the months of December, January, February, and March the Woods Hole temperatures are lower than those reported from Gloucester, despite the more northerly location of the latter station. This is probably due to the fact that the water used at the Gloucester station is in more immediate connection with the great reservoir of ocean water, which responds more slowly to the winter cold. Moreover, a rapid intermingling of the two is effected by the tides, which have a far greater amplitude at Gloucester than at Woods Hole.[a]

(4) During the months of May to November, inclusive, the water temperatures at Woods Hole are much higher than those of either of the more northerly stations, while the mean difference between Woods Hole and Gloucester for July, August, and September (7.1°) is over twice as great as that between Gloucester and Boothbay (3.5°).[b]

This last feature of the comparison is the most important of all for our present purposes. The difference in latitude between Woods Hole and Gloucester is about 1° 7′, while that between Gloucester and Boothbay is about 1° 12′. Nevertheless, the difference in water temperature between those two stations, which are separated by the peninsula of Cape Cod, is twice as great during the three months of the year when the water is warmest as that between the two stations lying to the north of Cape Cod, even though the latter are divided by a greater interval of latitude. While the waters whose temperatures are here recorded may not be entirely representative of the neighboring sea areas, and while the number of years here comprised is small, the main points in our comparison are believed to be sufficiently well established. Let us now return to a consideration of the temperature conditions at Woods Hole.

Significant features of the local temperature conditions.—If we take the average of all the temperature determinations (surface and bottom) recorded on chart 211 for the 14 stations westward of Robinsons Hole, within and at the entrance to Vineyard Sound, we find the mean temperature of these waters, at practically the period of maximum temperature, to be 62.17.° At Woods Hole this temperature is exceeded during the entire period of the year between June 14 and October 6. If we consider only the figures for bottom temperature in this western area of the Sound (and these it is, in the main, which influence the bottom fauna), we find the mean to be 60.24, a temperature which is exceeded at Woods Hole, from June 3 to October 11. In Buzzards Bay, on the other hand, a temperature as low as this last was not once recorded during the August series of observations, though in one case it was found just beyond the mouth of the Bay (V). Bottom temperatures between 60° and 65° were, however, found throughout the lower third or fourth of the Bay, except near the western shore.

It thus appears that the summer conditions of temperature such as obtain in the vicinity of Woods Hole during the months of June, July, August, and September do not directly affect the southwestern third of Vineyard Sound and in only a limited degree the lower end of Buzzards Bay. It will be shown that this fact is of supreme importance for the understanding of certain features of distribution.

It might reasonably have been expected that the winter temperature of these outlying waters, adjacent to the open sea, would be considerably higher than that

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[a] This is in full agreement with the explanation of the relatively high winter temperatures at Gloucester and Boothbay; independently offered by Superintendents Corliss and Hahn.

[b] This difference is likewise somewhat greater for October, and is practically the same for May.

elsewhere recorded within the region, owing to the conservative influence of the ocean in retaining the heat received during the summer. It would have given no surprise, therefore, to find the mean annual temperatures approximately the same throughout all these waters. Unfortunately we have no data for the coldest period of the winter. Reference to the temperature curves for the Woods Hole station shows that the water curve reaches its lowest level on February 19. It was planned, accordingly, to obtain a series of observations in Vineyard Sound and Buzzards Bay at about that date in 1908. It is a matter of much regret that no boat was available for this purpose until a month later, when the water temperature throughout the entire region had risen to nearly 37° F. At this time, as has already been pointed out (p. 44), a great uniformity in water temperature prevailed throughout the region explored, and the outlying waters, off Gay Head and Cuttyhunk, did not differ appreciably from those of the other portions of Vineyard Sound and Buzzards Bay. It will be recalled that in November there was likewise a large measure of uniformity, though at that time the outlying waters were somewhat warmer than the rapidly cooling waters of the upper half of the Bay. In the absence of further data it might be contended that at the time the November observations were made the inshore temperature was just passing the ocean temperature in its annual decline, while, on the other hand, it might be supposed that the March temperatures were taken at a time when the inshore temperature curve was again about to cross that for the ocean temperature. And indeed it is possible, that in the intervening months the latter did remain somewhat higher than the former.

But even on the impossible supposition that 36° F. represents the minimum temperature of these outlying waters,[a] this figure would be only about 7° higher than the lowest recorded elsewhere (i. e., the freezing point of sea water), whereas in summer the extremes of temperature varied as widely as 15°. Thus, in any case, the mean annual temperature of the bottom waters in the outlying portions of Vineyard Sound and Buzzards Bay is undoubtedly lower than that of the more inclosed areas to the northeast. For Vineyard Sound the mean bottom temperature of the stations lying to the seaward of Robinsons Hole, as based upon the four seasonal averages obtained by us, is 50.53°. The corresponding figure for the remainder of Vineyard Sound was found to be 53.31°. This difference, however, is entirely determined by the June and August results, so that for the summer months alone the difference would be about twice as great.

Another plain deduction from the foregoing figures is that the total annual range of temperature in these outlying waters is far less than in the more inclosed waters of the region. For the former the temperature range is probably about 30° F.; for the latter it may reach 45° or more.

The occurrence in summer of colder waters in the ocean immediately beyond the mouth of Vineyard Sound was pointed out by Verrill as long ago as 1871, and a few definite temperature figures were then presented by him. These last were also included in the chart accompanying the "Report on the Invertebrate Animals of Vineyard Sound." On September 9 the lowest figure recorded by Verrill was 57° F., which was the bottom temperature at a point several miles beyond Gay Head. Within the

[a] Rathbun (1887) in a chart (No. 17), giving temperatures taken during five years at the Vineyard Sound Lightship, off Sow and Pigs Reef, records figures as low as 29° and 30° during January and February. For most of the time during these months, moreover, the temperature remained below 35°. These were surface temperatures, it is true, but it is likely, as above stated, that the figures for surface and bottom are not far from equal in winter.

mouth of Vineyard Sound, on the same day, the surface temperature was 67° F. Temperatures were likewise taken west of No Mans Land and south of Narragansett Bay in 29 fathoms. These agree in being considerably lower than the temperatures known to occur at the same time in the more inclosed waters of the neighborhood. The present writers have found still more extreme conditions to prevail at certain points immediately to the east of Cape Cod. At Crab Ledge, a few miles to the east of Chatham (chart 223), at a mean depth of 17½ fathoms, two observations on August 12, 1909, gave a mean surface temperature of 65° F. and a mean bottom temperature of 47.2° F. These figures accord pretty well with some obtained at nearly the same point by Robert Platt, United States Navy, on September 14 and 15, 1877.[a] The latter found a mean surface temperature of 60.3° F. and a mean bottom temperature (28 fathoms) of 48.2° F. It is interesting to compare the figures obtained by us on August 10 and 12, 1909, for a series of points between Woods Hole and Crab Ledge. These are presented in the following table:

	Depth.	Surface temperature.	Bottom temperature.
Pollock Rip (just without Nantucket Sound)	5	63.0	62.0
Handkerchief Shoal (eastern end Nantucket Sound)	7	62.5	60.0
Cross Rip (middle of Nantucket Sound)	8¾	[a] 70.5	[a] 70.2
West Chop (eastern end Vineyard Sound)	12	71.0	69.5

[a] The mean of two determinations on different days.

Verrill explained the low temperatures of the outer waters by invoking the aid of "an offshoot of the arctic current," which he believed to pass westward into Long Island Sound. The question whether or not there is a definite southward (and westward) flowing current which affects this part of the coast has already been discussed briefly on another page. No conclusive answer to this question appears to be forthcoming at present. Undoubted, however, is the fact that during the summer months there lies a comparatively cold zone between the warm coastal water and the yet warmer Gulf Stream. This may, as has been suggested, merely represent the normal ocean water which would be proper to this latitude in the absence of the Gulf Stream. If this view be accepted, the higher temperature attained during the summer months by the waters of Buzzards Bay and of Nantucket and Vineyard Sounds is simply the result of their shallowness and comparative detachment from the great reservoir of ocean water outside, just as we know that salt marshes or shallow lagoons become even warmer than this during the summer months.

The question here suggests itself why the coastal waters north of Cape Cod, e. g., at Gloucester and at Boothbay, do not likewise become much warmer than they do during the summer months. We have seen (p. 49) that the relations between the temperatures at these points and those at Woods Hole are not such as are wholly explained by differences in latitude. It is highly probable that one factor in the case is the far greater depth of the waters north of Cape Cod, at slight distances from shore. For example, the 50-fathom line passes within from 5 to 10 (nautical) miles of Cape Ann and of many parts of the Maine coast; while at the nearest point it lies over 50

[a] These data were furnished us by the Superintendent of the Coast and Geodetic Survey.

miles from Marthas Vineyard. The tides, likewise, are of much greater amplitude north of Cape Cod, insuring a far more rapid intermingling of the coastal waters with those of the open sea. South of Cape Cod there is an extensive area of shoal water, much of which is pretty definitely bounded off from the open ocean. Reference has already been made to the occurrence of a net westerly tidal movement through Vineyard Sound. This implies, of course, that the latter derives much of its water from Nantucket Sound, a broad and on the whole very shallow area of sea, pretty well shut in by land and by shoals.

5. SALINITY.

Salinity or, more properly, density determinations were made along with those for temperature. The Sigsbee water cup was employed for obtaining samples from the bottom, while the surface water was merely drawn up in a pail. The salinometers employed were of the Hilgard pattern and were previously tested by the Bureau of Standards. Great care was taken to prevent the soiling of the stem by the hands, which was found to exert a marked effect upon the level reached by the instrument. A bottle of caustic soda solution, or a mixture of sulphuric acid and potassium bichromate, was kept at hand, and used from time to time for cleaning the stem. It was found more practicable to read from the summit of the meniscus, or cone of fluid surrounding the salinometer stem, than to read from the actual water level. The value of the meniscus in terms of the scale was later determined. Since the temperature of the water is an all important factor in determining its specific gravity, as referred to distilled water at maximum density, careful record was kept of the water temperature at the time of taking the reading for density. Knowing these two factors, reduction was easily accomplished by the aid of a table furnished by the Bureau of Standards.[a]

The figures, as presented, represent the specific gravities which would have been obtained had the water samples in all cases been at a temperature of 15° C. Thus each figure represents the relative weight of a given sample at 15° C. compared with an equal volume of distilled water at 4° C. The density of a solution depends, of course, upon two factors, its temperature and its concentration. Having eliminated all differences due to the former factor, the figures here given represent the concentration, i. e., the salinity of the water.

The density readings here recorded were in nearly all cases made aboard ship. More precise determinations would of course have been possible if the water samples had been bottled and brought back to the laboratory where the ship's motion would not have disturbed the observations.[b] And our results would have been still more precise had we resorted to the method of titration with nitrate of silver, as employed in recent hydrographic studies.[c] The latter method has, however, been used by us as a check upon our specific gravity determinations, and the results of the two accord so well on the whole (see p. 54) that the figures here presented are probably exact enough to meet the demands of the present work. Our figures for density are recorded to the fourth decimal place. From comparison with the chlorine tests it seems likely that in

[a] Various tables of this sort have been published; e. g., Libbey, 1891, p. 397; Tanner, 1897, p. 337.

[b] In five cases, in which this was done, and the results of the two independent determinations were compared, a mean difference of 0.00024 was found; i. e., the error affected only the fourth decimal place, or last one considered in making the reading.

[c] See Pettersson, 1894, p. 296; also account of International Conference for the Exploration of the Sea, in Journal of the Marine Biological Association, vol. VI, pp. 101–114.

some cases they are accurate only to the third decimal place. Those familiar with recent hydrographic studies will perhaps regard such figures as too rough approximations to have any scientific value. This would doubtless be true if we had to do with wide expanses of the sea, containing fairly permanent currents or strata of water, the limits of which could only be ascertained by determining slight differences of salinity. But in the inclosed bays and sounds of our region the continual intermixture of the waters resulting from tides and winds would render unlikely any constant stratification on the basis of salinity, and it is certain that rapid variations occur within the same area. As was the case with the temperature records already discussed, a series of determinations having no reference to the phase of the tide are open to rather serious objections. But it would be practically impossible to make such a series simultaneously throughout so large an area, and almost equally difficult to make each of them at a corresponding phase of the tide. For these reasons, therefore, only the larger differences of water density, such as are indicated by figures in the third decimal place, seem to be of interest in attempting any correlation between this factor and the distribution of our local marine animals and plants. And it will be found later that, so far as our dredging records are concerned, even the greatest extremes of salinity which are recorded by us have little or no effect in limiting the distribution of most of the species. This statement, of course, is only intended to apply to the fauna taken by the dredge. Great numbers of littoral or shallow-water organisms, here as elsewhere, obviously thrive best in brackish water or at least in somewhat diluted sea water. The salt marshes and the estuaries, indeed, are largely populated by a fauna of their own.

The figures for density are given in the same tables (1–8) as those for temperature. From the density figures those for salinity proper, or percentage of salts, may readily be obtained from the table offered by Pettersson (1894, p. 298). The following equivalents have been computed for such degrees of density as are to be found in Buzzards Bay and Vineyard Sound. They represent the percentages of salt by weight in a given quantity of sea water:

Density.	Salinity.	Density.	Salinity.
1.0210	2.84	1.0230	3.09
1.0215	2.91	1.0235	3.16
1.0220	2.98	1.0240	3.23
1.0225	3.03	1.0245	3.29

The differences of salinity, in relation to locality and season, are represented upon charts 215 to 218. Several facts of importance are to be derived from these tables and charts.

(1) Even the highest figure recorded here (1.0244) is considerably lower than that found throughout the north Atlantic at great distances from land, where a specific gravity of 1.0270 to 1.0280 prevails.

(2) The greatest extremes to be found among our determinations are 1.0212 and 1.0244, representing a difference of about 15 per cent in salinity.

(3) The average surface density (1.02337) is lower than the average density at the bottom (1.02349). This difference is more marked in the Bay than in the Sound. It is

manifested in six of the eight pairs of contrasted figures, the June figures (both for the Bay and Sound) being exceptions.

(4) The average density for Buzzards Bay (1.02314[a]) is lower than that for Vineyard Sound (1.02372) and is particularly low at the head of the Bay. This condition is readily understood by reference to the estuaries which discharge into it.

(5) Certain seasonal differences appear which are, perhaps, of questionable significance. In Vineyard Sound the density figures for the seasons may be arranged in the following order:

June	1.02339
March	1.02358
August	1.02387
November	1.02403

For Buzzards Bay the figures can not be given for the entire area, since in March only six stations, nearly all of them in the upper half, were visited. Taking the figures for these same six stations for the four months we find the following order to obtain:

March	1.02266
June	1.02273
November	1.02299
August	1.02327

The figures for the different seasons were obtained at intervals of about three months and by two different observers. Differences due to "personal equation" have thus perhaps played a part in the results. And even if that source of error were eliminated, it is quite likely that the figures for the same month in different years would not agree at all exactly. In November, 1908, eight of the determinations of the preceding November were repeated. The average difference between the earlier and later figures was 4 in the fourth decimal place, i. e., a quantity in excess of some of the seasonal differences appearing in the foregoing tables.

In order to compare the results of hydrometer readings with those obtained by titration for chlorine, 17 water samples were subjected to both tests.[b] The chlorine determination in each case was compared with the value, computed from Pettersson's table, for water of the specific gravity recorded. It was found that the actual and the expected values differed on the average by 1.5 per cent. On the assumption that the figures for the titrations were absolutely correct, which is scarcely allowable, this discrepancy implies an average error in the salinometer readings amounting to a little over 3 in the fourth decimal place. We have thus, in any case, some measure of the accuracy of the specific gravity determinations here recorded. As already stated, the fourth figure is not entirely trustworthy. It must be remembered, however, that local differences have been pointed out within our region equal to about ten times the amount of this average error.

Seven water samples obtained by us in August, 1909, at points within Nantucket Sound and beyond its eastern end, yielded specific gravities varying only from 1.0237 to 1.0239. These figures are close to, but slightly lower than, those found in Vineyard Sound during the same month two years previously.

[a] This figure is somewhat too low, since only the upper half of the Bay was represented in the March series. Here, as stated, the density is particularly low.

[b] These titrations were for the most part made by Dr. W. M. Clark, then a scientific assistant at the Woods Hole laboratory.

Chapter III.—SYNOPSIS OF ZOOLOGICAL DATA.

1. THE DREDGING RECORDS.

Complete records were kept of every dredge haul of the Survey, comprising such data as the bearings, date, depth, etc., at each station, as well as a list of the aggregate fauna and flora found to occur there. It was our original expectation to publish the entire set of station records as an appendix to the present report, for it would certainly be desirable to insure the permanency of these records through printing. They are the crude data upon which most of our ensuing discussion is based, and it is highly probable that they would yield other results of value if subjected to further analysis. Here, and here only, do we find what forms of life are associated together upon a given area of the sea bottom. Owing to the voluminous character of these records, however, it has not been found practicable to publish them in their entirety, although a "List of Stations" is presented at the close of section I. As regards the associations of species, we must be content at present with presenting the data in a generalized form, except for the reproduction of a very few complete station records by way of illustration.

In all there are 458 stations, belonging to the regular series, which may be classified as follows:

Fish Hawk, Vineyard Sound	218
Fish Hawk, Buzzards Bay	66
Fish Hawk, Crab Ledge	7
Phalarope and Blue Wing, Vineyard Sound	77
Phalarope, Buzzards Bay	90
Total	458

With a few exceptions (see below) these stations were all dredged during the summers of 1903, 1904, and 1905. The *Fish Hawk* was employed during all three of these seasons, the *Phalarope* (supplemented by the *Blue Wing*) during the second and third seasons. Owing, however, to an accident which prevented the use of the *Phalarope* along the western shore of Buzzards Bay in 1905, the latter region was not dredged until the summer of 1907. These 1907 stations have been charted along with the others and the records included in the same series. There are likewise included with the regular series certain repeated stations. Owing to the somewhat tentative character of the Vineyard Sound dredgings in 1903, 34 of these earlier stations were redredged (approximately) in 1904, partly with the *Fish Hawk*, partly with the *Phalarope*. Such stations have been designated by the original number, with the addition of the Latin word "bis." The "bis" stations have all been treated as *Fish Hawk* stations, and a list of them is published at the end of the *Fish Hawk* series. The records for the occurrence of each species at this group of repeated stations have been incorporated serially

with the others in the annotated list, and these records have been included in plotting the distribution charts.

During the summers of 1906, 1907, 1908, and 1909 various supplementary dredgings were carried on with both the *Fish Hawk* and the *Phalarope*, and at least 150 stations were dredged. These were in most cases more or less approximate repetitions of stations of the regular series. On most of these occasions search was made only for particular species, and no list was kept of the entire collection of organisms brought up. In the case of the hydroids, Bryozoa, and Foraminifera, however, and of unusual species belonging to any group, the records derived from these supplementary stations are to a large extent included with the others, the year of the dredging being indicated. During the summer of 1909, 26 of the earlier stations in Buzzards Bay (mainly of the *Fish Hawk* series) were repeated with rough approximation by the *Phalarope*, and fairly full lists were made of the organisms taken at each.[a] These lists have been appended to the regular series. Several trips were likewise made during the summer of 1907 for the special purpose of collecting algæ.

To what degree the earlier records have been confirmed or corrected by these supplementary dredgings will appear from time to time in the special discussion relating to particular species. It may be noted in passing, however, that the later operations have added very materially to the accuracy of our results as a whole.

A chart (no. 226) has been prepared indicating the position and, so far as possible, the direction and extent (see p. 18) of the dredgings of the survey. Upon this chart the stations are numbered, these numbers corresponding to those given in the lists. The numbers employed are arranged consecutively according to date. They do not therefore bear any necessary relation to the position of the stations. In order to facilitate the finding of a given station by the reader the following general statements are offered:

(1) The *Fish Hawk* stations are all indicated by numbers of four digits, commencing with 7, thus: 7521, etc. The *Phalarope* and *Blue Wing* stations are indicated by numbers ranging from 1 to 167.

(2) *Fish Hawk* stations are designated either by a circle or by a chain of two, three, or four smaller circles, connected by a straight or curved line (see p. 18). *Phalarope* and *Blue Wing* stations are designated by arrows, which show the direction of the haul, and, very roughly, its relative duration. These last are in all cases near shore, except for a few upon the Middle Ground shoal at the eastern end of Vineyard Sound.

(3) *Fish Hawk* stations 7521 to 7602 are in Vineyard Sound, commencing near Nobska Point and running to the westward. They are arranged at intervals of about three-fourths of a mile along lines crossing the Sound at a distance of about 1 mile from one another. Near the western end of Vineyard Sound three of these lines are numbered in a reversed order, i. e., stations 7581 to 7587 are along the line connecting Gay Head and Cuttyhunk, the next stations in serial order, being upon a line passing from Nashawena to a point about 1 mile east of Gay Head.

(4) Stations 7603 to 7609, inclusive, are at Crab Ledge (see chart 223), and are therefore not included upon the present chart.

(5) Stations 7610 to 7675 are in Buzzards Bay—7610 to 7635 are in the upper half, starting from a point near Woods Hole; 7636 to 7675 are in the lower half.

[a] Certain groups, however, did not receive adequate attention, and comparatively few of these specimens were referred to specialists for identification.

(6) Stations 7676 to 7783 (except 7711 to 7716) are in Vineyard Sound, beginning at the western end and passing eastward, though the order is not at all regular.

(7) Stations 7711 to 7716, inclusive, do not appear upon the chart.

(8) Stations 1 to 19, 24 to 43, and 52 to 167 were dredged by the *Phalarope;* 20 to 23 and 44 to 51 by the *Blue Wing.*

(9) Stations 1 to 77 are in Vineyard Sound. No. 1 is along the shore of Nonamesset Island. The first series continues, not always in regular order, to 38, at Cuttyhunk, though 35, 36, and 37 are at Sow and Pigs Reef. Stations 39 to 43 are along the shoal Middle Ground. Stations 44 to 51 and 56 to 60 are at Gay Head; 61, 62, and 63 are near West Chop; 64 to 68 are along the shore of Marthas Vineyard from Prospect Hill to Cedar Tree Neck; 69 to 72 are in Vineyard Haven; while stations 73 to 77 extend from Nortons Point to Cedar Tree Neck.

(10) Stations 78 to 167 are in Buzzards Bay. They commence at Nashawena Island, and extend northeastward along the shores of Pasque and Naushon; the series then skips to Cuttyhunk (99 to 104), then to Weepecket Islands (105 to 110), then to Cuttyhunk again (111 and 112) and to Penikese (113 to 116). Station 117 is at Uncatena Island, and 118 to 123 are in the immediate neighborhood of Woods Hole. From this point the series extends pretty regularly up the eastern shore of Buzzards Bay, and from the head of the Bay, down the western shore, at wider intervals.

The complete records of four of our stations (dredge hauls) are presented herewith. We have selected one *Fish Hawk* station in Buzzards Bay (7656), one *Fish Hawk* station in Vineyard Sound (7730), one *Phalarope* station in Vineyard Sound (52), and one *Phalarope* station in Buzzards Bay (83). In each case, that station, within each group, has been selected from which the greatest number of species was recorded. Thus, 61 species of animals and 20 species of plants were found at station no. 7656; 81 animals and 13 plants at no. 7730; 72 animals and 14 plants at no. 52; and 68 animals and 11 plants at no. 83. These are accordingly not typical dredge hauls in the sense of being average ones, numerically speaking.[a] On the other hand, the bottoms which were traversed were probably characteristic enough of the regions which they represent.

No attempt has been made by us, here or elsewhere, to count the number of *individual organisms* taken in a single haul of the dredge. Such figures are, however, so entirely dependent upon the character and size of the dredge employed, and the duration of the haul, that we do not believe that the value of any results of this sort would have been commensurate with the labor involved in counting.

Even these maximum figures from our dredging in Vineyard Sound and Buzzards Bay fall much below some of those offered by Herdman and Dawson (1902, p. 20 et seq.). For example, in three successive hauls in the neighborhood of Port Erin, at depths of 16 to 18 fathoms, these writers record 93, 111, and 156 species of animals. Moreover, we are informed that these hauls are "characteristic" and not "picked" ones, being made "for the purpose of comparison with some published from other seas." Further comparisons between the fauna of our region and that of the Irish Sea, in respect to wealth of species, will be found on pages 88 and 89.

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[a] The numbers for these stations are about twice the average ones. See p. 77.

FISH HAWK STATION 7656.

August 12, 1904.—North end Penikese Island W. by S., 3½ miles; Dumpling Rock Light NNW. ¾ W., 4⅞ miles; 8 fathoms; sandy mud; 7-foot beam trawl, scrape dredge; drift NE. ⅛ mile.

ANIMALS.

HYDROZOA:
- ?Obelia geniculata (on Laminaria).
- Tubularia crocea (few colonies).

BRYOZOA:
- Ætea anguina.
- Bugula turrita.
- Cellepora americana.
- Lepralia sp. (americana or pallasiana).
- Membranipora pilosa.
- Schizoporella unicornis.

ANNULATA:
- Arabella opalina (1).
- Brada setosa (1).
- Cistenides gouldii (1 tube).
- Clymenella torquata (several tubes).
- Diopatra cuprea (few tubes).
- Harmothoë imbricata (1 tube).
- Lumbrineris hebes (1).
- Nephthys incisa (several).
- Nicolea simplex (2 tubes on Laminaria).
- Ninoë nigripes (several).
- Rhynchobolus americanus (1).
- Spiochætopterus oculatus.
- Spirorbis spirorbis (on Laminaria, etc.).
- Trophonia affinis (several).

CIRRIPEDIA:
- Balanus sp. (probably eburneus) (few).

DECAPODA:
- Cancer irroratus (several).
- Libinia emarginata (several large and small).
- Neopanope texana sayi (1).
- Pagurus longicarpus (several in shells of Nassa).

AMPHIPODA:
- Æginella longicornis (1).
- Amphithoë rubricata (1).
- Caprella geometrica (1).
- Ptilocheirus pinguis (many).

ISOPODA:
- Erichsonella filiformis (1).

PELECYPODA:
- Anomia simplex.
- Arca transversa (few shells).
- Astarte castanea (several shells).
- Astarte undata (several shells).
- Callocardia morrhuana (few shells).
- Cardium pinnulatum (few shells).
- Clidiophora gouldiana (few).
- Ensis directus (few shells).
- Mytilus edulis (several large and small shells).

PELECYPODA—Continued.
- Nucula proxima.
- Petricola pholadiformis.
- Tellina tenera.
- Venus mercenaria (few small shells).
- Yoldia limatula (1).

GASTROPODA:
- Anachis avara (few shells).
- Astyris lunata.
- Crepidula fornicata (few shells and living).
- Crepidula plana (few shells).
- Littorina litorea (1 shell).
- Tritia trivittata (several shells).
- Turbonilla vinæ.
- Turbonilla winkleyi.
- Turbonilla sp.

CEPHALOPODA:
- Loligo pealii (eggs and young).

PISCES:
- Paralichthys oblongus (1).
- Prionotus carolinus.
- Pseudopleuronectes americanus (3).
- Spheroides maculatus (1).
- Stenotomus chrysops (many young).
- Urophycis tenuis (1 living).

PLANTS.

PHÆOPHYCEÆ:
- Chorda filum (1).
- Chordaria flagelliformis (many).
- Desmarestia aculeata (few).
- Dictyosiphon hippuroides (many).
- Ectocarpus fasciculatus (many).
- Laminaria Agardhii (many).

RHODOPHYCEÆ:
- Ahnfeldtia plicata (few).
- Callithamnion Baileyi (many).
- Ceramium rubrum (many).
- Champia parvula (few).
- Chondrus crispus (many).
- Cystoclonium purpurascens (few).
- Cystoclonium purpurascens var. cirrhosum (few).
- Dasya elegans (1).
- Phyllophora Brodiæi (many).
- Polysiphonia elongata (1).
- Polysiphonia nigrescens (few).
- Rhodomela subfusca (1).
- Rhodymenia palmata (1).
- Spyridia filamentosa (few).

FISH HAWK STATION 7730.

August 8, 1905.—(*a*) Prospect Hill-Nashawena, 115° 59′, Nashawena-Gay Head, 87° 59′; (*b*) Prospect Hill-Pasque, 92° 27′, Pasque-Gay Head, 115° 22′; (*c*) Prospect Hill-Pasque, 101° 57′, Pasque-Gay Head, 118° 41′; 12 fathoms; hard sand; 9-foot beam trawl and mud bag.

ANIMALS.

FORAMINIFERA:
- Biloculina ringens.
- Discorbina rosacea.
- Miliolina seminulum.
- Rotalia beccarii.

PORIFERA:
- Cliona celata (much).

HYDROZOA:
- Eudendrium dispar.
- Halecium halecinum.
- Hydractinia echinata.
- ?Obelia geniculata.
- Pennaria tiarella.

BRYOZOA:
- Ætea anguina.
- Bicellaria ciliata.
- Bugula turrita.
- Cellepora americana.
- Hippuraria armata.
- Lichenopora verrucaria.
- Membranipora tenuis.
- Schizoporella unicornis.
- Smittia trispinosa nitida.

ASTEROIDEA:
- Asterias forbesi (1).
- Asterias vulgaris (2).
- Henricia sanguinolenta (1 large).

OPHIUROIDEA:
- Amphipholis squamata.

ECHINOIDEA:
- Echinarachnius parma (2 shells and 1 living).

ANNULATA:
- Diopatra cuprea (1 tube).
- Harmothoë imbricata (1).
- Lepidonotus squamatus.
- Nicolea simplex (3).
- Pseudopotamilla oculifera (many tubes).
- ?Spirorbis spirorbis (few).

COPEPODA:
- Argulus megalops (1).

DECAPODA:
- Cancer irroratus (several).
- Crago septemspinosus (1).
- Homarus americanus (several).
- Libinia emarginata (many small).
- Ovalipes ocellatus (few).
- Pagurus acadianus (several).
- Pagurus annulipes (several).
- Pagurus longicarpus (few).

AMPHIPODA:
- Æginella longicornis (very many large and small).
- Ampelisca macrocephala (1).
- Ampelisca spinipes (3).
- Amphithoë rubricata (1).
- Byblis serrata (4).
- Corophium cylindricum (2).
- Ericthonius minax (4 males, 1 female).
- Ericthonius rubricornis (1 female).
- Pontogenia inermis (10 small).
- Unciola irrorata (2 small).

ISOPODA:
- Edotea montosa (1).
- Erichsonella filiformis (2).
- Idothea phosphorea (several).

PELECYPODA:
- Anomia simplex (many shells).
- Astarte undata (several shells).
- Callocardia morrhuana.
- Cardium pinnulatum (few living and shells).
- Clidiophora gouldiana (1 living and 1 shell).
- Cyclas islandica (1 shell).
- Divaricella quadrisulcata (1 shell).
- Ensis directus (1 shell).
- Lyonsia hyalina (3 shells).
- Modiolaria nigra (few very small living).
- Mytilus edulis (1 living).
- Nucula proxima (1 shell).
- Pecten gibbus borealis (1 fragment and 1 shell).
- Pecten magellanicus (1 fragment).
- Spisula solidissima (several shells).
- Tellina tenera (few living and 1 shell).
- Venericardia borealis (few shells).
- Venus mercenaria (1 large shell).

GASTROPODA:
- Anachis avara (few).
- Astyris lunata.
- Lacuna puteola (2).
- Polynices heros (several).
- Tritia trivittata (few living and shells).
- Vermicularia spirata (1 shell).

CEPHALOPODA:
- Loligo pealii.

TUNICATA:
- Amaroucium stellatum.

PISCES:
- Pseudopleuronectes americanus (3).
- Raja erinacea (3).
- ?Raja ocellata (1).

PLANTS.

PHÆOPHYCEÆ:
- Chorda filum (drifted fragments).
- Desmarestia aculeata (few).
- Desmarestia viridis (few).
- Dictyosiphon hippuroides (few).
- Fucus vesiculosus (drifted fragment).
- Sargassum Filipendula (drifted fragments).

RHODOPHYCEÆ:
- Agardhiella tenera (few).
- Antithamnion cruciatum (few).
- Ceramium tenuissimum (few).
- Cystoclonium purpurascens var. cirrhosum (many).
- Grinnellia americana (1).
- Polysiphonia elongata (few).
- Polysiphonia nigrescens (many).

PHALAROPE STATION 52.

August 11, 1904.—7–6½ fathoms; shelly and gravelly.

ANIMALS.

HYDROZOA:
- Tubularia crocea (few tubes).

BRYOZOA:
- Bugula turrita (many).

ASTEROIDEA:
- Asterias forbesi (several).
- Asterias vulgaris (several).
- Henricia sanguinolenta (2).

ECHINOIDEA:
- Arbacia punctulata (few).
- Echinarachnius parma (many).
- Strongylocentrotus droebachiensis (several living).

ANNULATA:
- Diopatra cuprea (many tubes).
- Harmothoë imbricata (common).
- Hydroides dianthus (few).
- Nephthys incisa (1 fragment).
- Nereis pelagica (several).
- Pista sp. (fragment of 1 tube).
- Pseudopotamilla oculifera (1).
- Sabellaria vulgaris (1 tube).

DECAPODA:
- Cancer irroratus (many small).
- Crago septemspinosus.
- Libinia emarginata (several small).
- Pagurus acadianus (2 small).
- Pagurus annulipes (few).
- Pagurus longicarpus (many).

AMPHIPODA:
- Corophium cylindricum (1).
- Ischyrocerus anguipes (1 small).
- Unciola irrorata (1).

ISOPODA:
- Erichsonella filiformis.

PELECYPODA:
- Anomia aculeata (1 shell).
- Anomia simplex (few shells).
- Arca transversa (few living and shells).

PELECYPODA—Continued.
- Astarte castanea (several).
- Astarte undata (few).
- Callocardia morrhuana (many shells).
- Cardium pinnulatum (common, living).
- Clidiophora gouldiana (many shells).
- Cochlodesma leanum (abundant).
- Corbula contracta (1 shell).
- Crassinella mactracea (many living).
- Crenella glandula.
- Cumingia tellinoides (few shells).
- Ensis directus (small living).
- Lyonsia hyalina (1 living).
- Modiolaria nigra (few shells).
- Modiolus modiolus (few shells).
- Mulinia lateralis (few shells).
- Mytilus edulis (few).
- Nucula proxima (few).
- Pecten magellanicus (1 shell).
- Petricola pholadiformis (2 shells).
- Spisula solidissima (many shells).
- Tellina tenera (few shells).
- Venericardia borealis.
- Venus mercenaria (few shells).
- Yoldia limatula (1 shell).

GASTROPODA:
- Anachis avara (several shells).
- Astyris lunata (many living).
- Busycon canaliculatum (1).
- Cæcum cooperi.
- Cerithiopsis emersonii (1 shell).
- Crepidula convexa (several living).
- Crepidula fornicata (many shells).
- Crepidula plana (many living).
- Lacuna puteola (few shells).
- Littorina rudis (1 living, 2 shells).[a]
- Polynices duplicata (few, 1 living).
- Polynices heros (few shells).
- Polynices triseriata (several living and shells).
- Tritia trivittata (living and many shells).

[a] The occurrence of this species in the present dredge haul is inexplicable The specimens doubtless came from much nearer shore, being retained in the net, perhaps, from the preceding haul.

GASTROPODA—Continued.
- Urosalpinx cinereus (few).

AMPHINEURA:
- Chætopleura apiculata (several).

CEPHALOPODA:
- Loligo pealii (1 mass of eggs).

PISCES:
- Myoxocephalus æneus (few).
- Raja sp., egg capsule (1).

PLANTS.

PHÆOPHYCEÆ:
- Chordaria flagelliformis (few).
- Ralfsia clavata (few).

RHODOPHYCEÆ:
- Agardhiella tenera (many).
- Antithamnion cruciatum (few).
- Corallina officinalis (few).
- Cystoclonium purpurascens (few).
- Cystoclonium purpurascens var. cirrhosum (few).
- Griffithsia Bornetiana (few).
- Lithothamnion polymorphum (few).
- Phyllophora Brodiæi (few).
- Polysiphonia nigrescens (many).
- Rhodymenia palmata (few).
- Seirospora Griffithsiana (many).
- Spyridia filamentosa (many).

PHALAROPE STATION 83.

July 12, 1905.—North shore of Pasque Island; 5–7 fathoms; sand.

ANIMALS.

FORAMINIFERA:
- Miliolina circularis.

PORIFERA:
- Cliona celata (2 pieces).

HYDROZOA:
- Hydractinia echinata.
- Sertularia sp.
- Thuiaria argentea.
- Tubularia crocea (dead tubes).

ACTINOZOA:
- Astrangia danæ (several small).

BRYOZOA:
- Ætea anguina.
- Bugula turrita.
- Crisia eburnea (few).
- Hippothoa hyalina.
- Lepralia sp. (americana or pallasiana).
- Membranipora pilosa.
- Membranipora tenuis.
- Schizoporella unicornis.
- Smittia trispinosa nitida.

ASTEROIDEA:
- Asterias vulgaris (1 small).
- Henricia sanguinolenta (1 small).

ECHINOIDEA:
- Arbacia punctulata (spines).
- Echinarachnius parma (1 shell).

ANNULATA:
- Diopatra cuprea (few tubes).
- Harmothoë imbricata (2 very small).
- Hydroides dianthus (several).
- Lepidonotus squamatus (1).
- Nereis arenaceodentata (1).
- Nereis pelagica (1 young).
- Pista sp. (fragments of several tubes).
- Spirorbis sp. (2 tubes).

CIRRIPEDIA:
- Balanus sp. (probably eburneus) (few).

SCHIZOPOD:
- Schizopod (undetermined).

DECAPODA:
- Crago septemspinosus (many).
- Homarus americanus (1 fragment).
- Libinia emarginata.
- Pagurus annulipes (several).
- Pagurus longicarpus (common).

AMPHIPODA:
- Leptochelia savignyi.

ISOPODA:
- ?Edotea acuta (1).

INSECTA:
- Sarcophaga sp. larva (probably not actually dredged from bottom).

PELECYPODA:
- Arca transversa (several).
- Astarte castanea (few living).
- Callocardia morrhuana (few).
- Cardium pinnulatum (several shells).
- Clidiophora gouldiana (1 living).
- Corbula contracta (few shells).
- Crassinella mactracea (several living and shells).
- Crenella glandula (2 shells).
- Cumingia tellinoides (2 shells).
- Ensis directus (shells).
- Mytilus edulis (fragments and young).
- Ostrea virginica (1 living).
- Pecten gibbus borealis (2 shells).
- Yoldia limatula (few, 1 living).

AMPHINEURA:
- Chætopleura apiculata (2).

GASTROPODA:
- Anachis avara (common, living and shells).
- Astyris lunata.
- Cochlodesma leanum (1 shell).
- Crepidula convexa (1 living).
- Crepidula fornicata (many shells).
- Crepidula plana (few).
- Eupleura caudata (several shells).
- Littorina litorea (1 shell).
- Polynices triseriata (common, living and shells).
- Tritia trivittata (many living).
- Urosalpinx cinereus (few shells).
- Vermicularia spirata (several shells).

TUNICATA:
- Didemnum lutarium (several masses).
- Molgula manhattensis (2).

PISCES:
- Myoxocephalus æneus.

PLANTS.

PHÆOPHYCEÆ:
- Desmarestia aculeata (many).
- Leathesia difformis (1 drift).

RHODOPHYCEÆ:
- Callithamnion roseum (2).
- Corallina officinalis (1 drift).
- Cystoclonium purpurascens var. cirrhosum (many).
- Phyllophora Brodiæi (many).
- Phyllophora membranifolia (many).
- Polyides rotundus (many).
- Polysiphonia nigrescens (many).
- Polysiphonia urceolata (1).
- Rhodomela subfusca (1).

2. THE DISTRIBUTION CHARTS.

We have deemed it advisable to publish a large number of charts portraying the distribution of species as revealed by the station records. It is not likely that the lists of station numbers given in the text for each species will often be translated by the reader into definite localities; while, on the other hand, the generalized statements of the authors are necessarily incomplete and at best do not take the place of graphic representations such as the charts. Some explanation is necessary for a proper understanding of these last. With a few exceptions, they are based upon the records of the regular dredging stations only, i. e., those for the years 1903, 1904, and 1905.[a] No data derived from outside information, however reliable, have been included here, nor even data from our own shore collecting, or (exceptions aside) from our supplementary dredgings and repetitions of earlier stations, though, of course, such additional data have been incorporated in the text. The exceptions mentioned include the "bis" stations as a whole (see p. 55), the records from which have been plotted for all species. In the case of the Foraminifera, hydroids, and Bryozoa, many records derived from supplementary dredgings (repeated stations) during the summers of 1906–1909 have been plotted upon the charts. This has been considered advisable owing to the probable imperfection of the original records for all of these organisms.

Such procedure is open to two objections. In the first place, the repeated stations are at best rather rough approximations to the original ones whose numbers have been given them. Even with the greatest care, it is impossible to lower a dredge at precisely the same point as on a previous occasion, and in the case of most of our repetitions, lack of time prevented the maneuvering necessary to a very exact location of the spot originally charted. In the second place, the repeated stations were not distributed with any regularity throughout the region dredged, and unless due caution is exercised the results of these are likely to be misleading. Moreover, since the records from these have been plotted only for certain groups, undue emphasis has in some cases probably been thrown upon the latter. Despite these objections, however, we believe that the distributions

[a] Including the completion of the western shore of Buzzards Bay in 1907.

of the species in question have been portrayed more fairly, on the whole, than if the supplementary records had been omitted.

Without making certain allowances one might be greatly misled by these charts. Some of the sources of possible misconception have just been referred to. For all groups the greater apparent abundance of various species in Vineyard Sound, as compared with Buzzards Bay, is frequently to be explained merely by the greater number of dredging stations in the former. The *Fish Hawk* was employed during two seasons upon the Vineyard Sound series of stations, while systematic dredging by this vessel in Buzzards Bay was limited to the summer of 1904. Thus there are 218 *Fish Hawk* stations in Vineyard Sound and only 66 in Buzzards Bay, although the latter is a considerably larger body of water. The concentration of stations in the Sound, so obvious upon the chart, is thus explained. The latter condition is emphasized by the inclusion in the distribution charts of records from the "bis" stations (see above), all of which were in Vineyard Sound. This disparity in the thoroughness with which the two bodies of water were worked was due (1) to the fact that the earlier and more or less experimental dredgings were conducted in Vineyard Sound, and it was regarded as desirable to repeat these; and (2) to the greater uniformity of conditions throughout the bottom of Buzzards Bay, rendering it unnecessary to dredge at such frequent intervals.

Another point for which allowance must be made is the fact that the apparent absence of a species from a given area is in some cases due merely to the absence, for the time, of a collector accustomed to search for this particular form, or even to the lack of dredging apparatus suitable for bringing it up. Such cases, and other possible sources of error, will be discussed in their proper places in connection with particular groups of animals.

Finally, reference must be made to certain spurious distribution patterns, which result, not from any defect in our own methods, but from the transportation of organic remains to points where the animals themselves had probably never lived. As an illustration of this phenomenon we may mention the occurrence of shells of the common oyster in the deeper parts of Vineyard Sound, where their presence is probably to be attributed to passing vessels. Another instance is the transportation of littoral shells (e. g., *Littorina litorea*) by hermit crabs, and it is likely that the lighter shells of certain mollusks and the remains of various other organisms are carried to considerable distances by currents.

The distribution charts are reproduced from maps plotted out by Mr. James W. Underwood and Miss Edith Chapman. These assistants employed a blank form based upon a chart prepared by the draftsman of the Bureau, Mr. W. F. Hill. The stars were first put in with a rubber stamp and then filled out with a drawing pen and india ink. Owing to the crowding of stations or the proximity of some of these to shore, the star is, in many cases, at some distance from the station to which it belongs.

It has not been thought worth while to plot the distributions of any species which were taken at less than 10 of the stations. On the other hand, the distributions of all animals,[a] with a few special exceptions, which were listed from 10 or more stations have been presented herewith. Thus the charts are restricted to the more representa-

[a] This statement does not strictly hold for the plants.

tive species comprised in our local benthos. In many cases, however, highly instructive data have been obtained regarding forms of less frequent occurrence. Such have been referred to in the text.

Records entered as doubtful have been excluded in plotting the distribution charts. In the charts for the shell-bearing mollusks and echinoderms, and for the coral *Astrangia*, it will be found that the stars are in many cases surrounded by circles. The circle in each case indicates that one or more *living* specimens were recorded from the station in question; absence of the circle implies either that the records indicate the presence of dead shells only, or that no statement has been made on the subject.

3. THE FAUNA CONSIDERED ACCORDING TO REGIONS AND HABITATS.

Many of the species encountered during our dredging operations were found to have a practically unrestricted distribution within the waters explored. In the case of many other species, their distribution was found to be definitely restricted, i. e., they were adapted to particular temperatures or to particular kinds of bottom. These various types of distribution will be discussed at some length in relation to particular species which serve to illustrate them, and many cases are portrayed graphically by means of charts. But it is likewise important that a list of the more prevalent species should be presented synoptically for each subregion of our chart and for each variety of habitat. With this in view the stations were tabulated in various ways, according to the type of bottom or the like; and for each of these groups lists were prepared comprising all of those species which were taken at one-fourth or more of the stations in question.[a] We believe that lists thus restricted may be regarded as comprising only such species as are truly representative of these various bottoms. It must be conceded, however, that many of the less common forms which do not appear in the lists at all may be highly characteristic of one or another group of stations, and may, indeed, be limited to these.

Preceding the lists for particular waters or particular types of bottom we present a table comprising those species which were taken at one-fourth or more of the total number of dredging stations of the Survey, i. e., at 115 or more of the regular stations.[b] It is believed that such a list conveys a good idea of the prevailing benthic fauna of our local waters, so far as we can speak of any single prevailing fauna where the conditions differ so widely. This list will perhaps render possible the detection of future changes in the relative abundance of certain species.

[a] At first only those species were listed which were present at half or more of a given group of stations, but it was found that all of the resulting lists were very brief, and that they omitted many highly characteristic forms.

[b] None of the supplementary stations, except the "bis" stations of 1904, have been considered in the present computations. The inclusion of the 1909 records would doubtless change the complexion of these tables somewhat, though not, we believe, very materially.

I. *Species recorded from one-fourth (115) or more of the regular dredging stations of the Survey.*[a]

PORIFERA:
- Cliona celata (171).

ACTINOZOA:
- Astrangia danæ (158).

BRYOZOA:
- Crisia eburnea (201).
- *Bugula turrita (255).
- Schizoporella unicornis (197).
- Smittia trispinosa nitida (163).

ASTEROIDEA:
- Henricia sanguinolenta (118).
- Asterias forbesi (206).

ECHINOIDEA:
- Arbacia punctulata (156).
- Echinarachnius parma (170).

ANNULATA:
- Harmothoë imbricata (189).
- Lepidonotus squamatus (165)
- Nereis pelagica (192).
- Diopatra cuprea (198).
- *Hydroides dianthus (237).

CIRRIPEDIA:
- Balanus eburneus (162).

AMPHIPODA:
- Unciola irrorata (115).

DECAPODA:
- Crago septemspinosus (169).
- *Pagurus longicarpus (290).
- Pagurus annulipes (196).

DECAPODA—Continued.
- Libinia emarginata (192).
- Cancer irroratus (209).
- Neopanope texana sayi (143).

PELECYPODA:
- *Anomia simplex (256).
- Pecten gibbus borealis (162).
- Mytilus edulis (217).
- Modiolus modiolus (120).
- *Arca transversa (264).
- Nucula proxima (205).
- Crassinella mactracea (182).
- Cardium pinnulatum (219).
- Callocardia morrhuana (192).
- Tellina tenera (193).
- *Ensis directus (235).
- Spisula solidissima (222).
- *Clidiophora gouldiana (234).
- Corbula contracta (128).

GASTROPODA:
- *Tritia trivittata (373).
- *Anachis avara (295).
- *Astyris lunata (245).
- Urosalpinx cinereus (156).
- Littorina litorea—*shells only* (131).
- *Crepidula fornicata (326).
- *Crepidula plana (291).
- Polynices heros (165).
- Polynices triseriata (144).

II. *Species which were taken at one-fourth (55) or more of the Fish Hawk stations in Vineyard Sound.*

PORIFERA:
- Cliona celata (76).

HYDROZOA:
- Eudendrium ramosum (58).
- Hydractinia echinata (62).

ACTINOZOA:
- Astrangia danæ (70).

BRYOZOA:
- Crisia eburnea (97).
- Bugula turrita (135).
- Schizoporella unicornis (112).
- Smittia trispinosa nitida (84).
- Cellepora americana (55).

ASTEROIDEA:
- Henricia sanguinolenta (62).
- Asterias forbesi (119).
- Asterias vulgaris (73).

ECHINOIDEA:
- Arbacia punctulata (101).
- Echinarachnius parma (130).

ANNULATA:
- Harmothoë imbricata (90).
- Lepidonotus squamatus (86).
- Nereis pelagica (115).
- Diopatra cuprea (75).
- Hydroides dianthus (94).

CIRRIPEDIA:
- Balanus eburneus (83).

DECAPODA:
- Crago septemspinosus (73).
- Pagurus pollicaris (70).
- Pagurus longicarpus (131).
- Pagurus annulipes (77).
- Libinia emarginata (99).
- Cancer irroratus (134).

[a] The number in parenthesis indicates the number of stations at which the species was found. Species are starred (in the first list only), which were taken at one-half or more of the stations.

AMPHIPODA:
- Unciola irrorata (68).

PELECYPODA:
- Anomia simplex (93).
- Mytilus edulis (136).
- Modiolus modiolus (85).
- Arca transversa (116).
- Nucula proxima (82).
- Venericardia borealis (59).
- Astarte castanea (74).
- Crassinella mactracea (90).
- Cardium pinnulatum (66).
- Callocardia morrhuana (62).
- Tellina tenera (77).
- Ensis directus (94).
- Spisula solidissima (140).

PELECYPODA—Continued.
- Clidiophora gouldiana (94).
- Corbula contracta (64).

GASTROPODA:
- Tritia trivittata (163).
- Anachis avara (131).
- Astyris lunata (116).
- Urosalpinx cinereus (63).
- Crepidula fornicata (144).
- Crepidula plana (136).
- Polynices heros (119).

CEPHALOPODA:
- Loligo pealii (55).

TUNICATA:
- Amaroucium pellucidum (57).

In a considerable measure the above list is a repetition of the first. Only four species comprised in the first list are wanting in the second, while only nine additional ones are to be found in the latter. This close agreement is doubtless due to the fact that the *Fish Hawk* stations in Vineyard Sound are more than three times as numerous as are those in Buzzards Bay. They thus have an undue share in determining the character of the first of our lists.

III. *Species taken at one-fourth (17) or more of the Fish Hawk stations in Buzzards Bay.*

PORIFERA:
- Cliona celata (32).

ACTINOZOA:
- Astrangia danæ (29).

BRYOZOA:
- Crisia eburnea (24).
- Ætea anguina (22).
- Bugula turrita (35).
- Schizoporella unicornis (31).
- Smittia trispinosa nitida (25).

ASTEROIDEA:
- Asterias forbesi (23).

ANNULATA:
- Nephthys incisa (34).
- Diopatra cuprea (34).
- Ninoë nigripes (31).
- Rhynchobolus americanus (22).
- Chætopterus pergamentaceus (21).
- Spiochætopterus oculatus (28).
- Cistenides gouldii (19).
- Clymenella torquata (25).
- Hydroides dianthus (30).

CIRRIPEDIA:
- Balanus eburneus (36).

AMPHIPODA:
- Ampelisca macrocephala (17).
- Ptilocheirus pinguis (26).
- Unciola irrorata (22).

DECAPODA:
- Crago septemspinosus (28).
- Pagurus longicarpus (52).
- Pagurus annulipes (27).
- Libinia emarginata (39).
- Cancer irroratus (26).
- Neopanope texana sayi (31).

PELECYPODA:
- Anomia simplex (52).
- Pecten gibbus borealis (32).
- Mytilus edulis (17).
- Arca transversa (50).
- Nucula proxima (37).
- Yoldia limatula (44).
- Crassinella mactracea (21).
- Cardium pinnulatum (55).
- Lævicardium mortoni (26).
- Venus mercenaria (34).
- Callocardia morrhuana (56).
- Tellina tenera (37).
- Macoma tenta (19).
- Ensis directus (40).
- Mulinia lateralis (45).
- Clidiophora gouldiana (52).

GASTROPODA:
- Busycon canaliculatum (32).
- Tritia trivittata (65).
- Anachis avara (37).

GASTROPODA—Continued.
- Astyris lunata (18).
- Eupleura caudata (40).
- Urosalpinx cinereus (18).
- Littorina litorea (28).
- Crepidula fornicata (55).

GASTROPODA—Continued.
- Crepidula plana (46).
- Polynices duplicata (21).
- Polynices triseriata (30).

CEPHALOPODA:
- Loligo pealii (18).

The number of species in the foregoing list (55) is slightly greater than that in the one immediately preceding it (51). It will be shown later that the average number of species per dredge haul was likewise somewhat greater in Buzzards Bay. This is true despite the fact that in the aggregate about 25 per cent more species were taken in Vineyard Sound than in Buzzards Bay. Of the 55 species contained in the foregoing table, 33 (55 per cent) are common to the list for the *Fish Hawk* stations in Vineyard Sound, while 22 are to be regarded as more particularly characteristic of Buzzards Bay. On the other hand, 18 of the more prevalent species in the Sound list do not appear in that for the Bay. Of the 22 characteristic Bay-dwelling species, 7 are annelids and 11 are mollusks; the 18 species peculiar to the Vineyard Sound list are more diversified.

The *Phalarope* and *Blue Wing* stations represent dredgings in the shoaler waters, and are for the most part much closer to land than those of the *Fish Hawk*. The more prevalent species from these stations will therefore be presented in separate lists.

IV. *Species taken at one-fourth (19) or more of the Phalarope and Blue Wing stations in Vineyard Sound.*

PORIFERA:
- ?Grantia ciliata (21).
- Cliona celata (32).

HYDROZOA:
- Tubularia crocea (27).

ACTINOZOA:
- Astrangia danæ (26).

BRYOZOA:
- Crisia eburnea (50).
- Bugula turrita (42).
- Schizoporella unicornis (29).
- Smittia trispinosa nitida (25).

ASTEROIDEA:
- Henricia sanguinolenta (36).
- Asterias forbesi (24).

ECHINOIDEA:
- Echinarachnius parma (31).

ANNULATA:
- Harmothoë imbricata (40).
- Lepidonotus squamatus (37).
- Nereis pelagica (51).
- Diopatra cuprea (35).
- Hydroides dianthus (47).

AMPHIPODA:
- Amphithoë rubricata (26).
- Corophium cylindricum (21).

ISOPODA:
- Idothea phosphorea (30).
- Erichsonella filiformis (25).

DECAPODA:
- Crago septemspinosus (27).
- Pagurus longicarpus (46).
- Pagurus annulipes (44).
- Libinia emarginata (29).
- Cancer irroratus (33).
- Neopanope texana sayi (23).

PELECYPODA:
- Anomia simplex (41).
- Anomia aculeata (28).
- Pecten gibbus borealis (26).
- Mytilus edulis (42).
- Arca transversa (36).
- Nucula proxima (25).
- Crassinella mactracea (32).
- Cardium pinnulatum (35).
- Callocardia morrhuana (20).
- Tellina tenera (31).
- Ensis directus (33).
- Cumingia tellinoides (23).
- Spisula solidissima (35).
- Clidiophora gouldiana (28).

GASTROPODA:
- Tritia trivittata (59).
- Anachis avara (63).
- Astyris lunata (57).
- Urosalpinx cinereus (36).
- Littorina litorea (19).

GASTROPODA—Continued.
- Lacuna puteola (39).
- Crepidula fornicata (55).
- Crepidula plana (50).
- Polynices heros (27).
- Polynices triseriata (35).

TUNICATA:
- Amaroucium pellucidum (25).
- Amaroucium pellucidum constellatum (**23**).
- Didemnum lutarium (24).

PISCES:
- Myoxocephalus æneus (22).

The number of species here comprised is very close to those in the two lists immediately preceding it. Of the 54 species here present, 38 (70 per cent) were contained in the list for the *Fish Hawk* stations of Vineyard Sound, 16 being wanting from the latter. Conversely, the *Fish Hawk* list contained 13 species which do not appear in that for the *Phalarope*. It does not follow, by any means, that a species which is limited to one or the other of these lists is actually restricted as to depth or proximity to shore. Indeed, most of them appear with considerable frequency in the dredgings of both vessels. Of the 16 species which are confined to the *Phalarope* list, only 3 show a marked restriction to the vicinity of the shore line. These are *Amphithoë rubricata*, *Lacuna puteola*, and *Littorina litorea*. The last named, as is well known, is strictly littoral (i. e., intertidal) in its habitat. The dredging records refer exclusively to shells, most or all of which were doubtless transported from the shore by hermit crabs. On the other hand, of the 13 species restricted to the *Fish Hawk* list, only 6 give any evidence of a preference for deeper waters than those dredged by the *Phalarope* and *Blue Wing*. These are *Eudendrium ramosum*, *Cellepora americana*, *Asterias vulgaris*, *Modiolus modiolus*, *Venericardia borealis*, and *Astarte castanea*. In the case of the last two species named, the avoidance of the inshore waters is quite obvious. Of the others this can not be stated as confidently.

V. *Species taken at one-fourth (23) or more of the Phalarope stations in Buzzards Bay.*

PORIFERA:
- Cliona celata (31).

HYDROZOA:
- Hydractinia echinata (33).

ACTINOZOA:
- Astrangia danæ (33).

BRYOZOA:
- Crisia eburnea (30).
- Bugula turrita (45).
- Schizoporella unicornis (25).
- Smittia trispinosa nitida (29).

ASTEROIDEA:
- Asterias forbesi (39).

ECHINOIDEA:
- Arbacia punctulata (29).

ANNULATA:
- Harmothoë imbricata (40).
- Lepidonotus squamatus (28).
- Diopatra cuprea (53).
- Pista palmata (25).
- Clymenella torquata (24).
- Hydroides dianthus (66).

CIRRIPEDIA:
- Balanus eburneus (27).

DECAPODA:
- Crago septemspinosus (41).
- Pagurus longicarpus (59).
- Pagurus annulipes (48).
- Libinia emarginata (25).
- Neopanope texana sayi (37).

PELECYPODA:
- Anomia simplex (68).
- Pecten gibbus borealis (61).
- Arca transversa (62).
- Nucula proxima (61).
- Yoldia limatula (26).
- Crassinella mactacea (39).
- Cardium pinnulatum (62).
- Lævicardium mortoni (60).
- Venus mercenaria (41).
- Callocardia morrhuana (54).
- Tellina tenera (48).
- Ensis directus (68).
- Cumingia tellinoides (38).
- Spisula solidissima (28).
- Mulinia lateralis (30).
- Lyonsia hyalina (31).
- Clidiophora gouldiana (59).
- Corbula contracta (36).

AMPHINEURA:
Chætopleura apiculata (23).

GASTROPODA:
Busycon canaliculatum (24).
Tritia trivittata (85).
Anachis avara (64).
Astyris lunata (54).
Eupleura caudata (37).
Urosalpinx cinereus (39).

GASTROPODA—Continued.
Bittium alternatum (37).
Littorina litorea (54).
Crepidula fornicata (72).
Crepidula convexa (32).
Crepidula plana (58).
Polynices duplicata (36).
Polynices triseriata (30).

TUNICATA:
Didemnum lutarium (27).

The total number of species in the foregoing list (54) is exactly the same as that contained in the one immediately preceding it. In fact there has been a rather striking uniformity in the numbers comprised in these lists, ranging as they do from 46 to 55. Of the 54 species in the foregoing table, 41 (76 per cent) are common to this and to the list of *Fish Hawk* species in Buzzards Bay. On the other hand, a number not much inferior to this (37=69 per cent[a]) are common to the present list and to that given for the *Phalarope* stations of Vineyard Sound, among the latter being some which are not recorded in the other Buzzards Bay list. A few others in this list are only found elsewhere in the *Fish Hawk* list for Vineyard Sound.

While, therefore, the *Phalarope* list for Buzzards Bay resembles the *Fish Hawk* list for Buzzards Bay more closely than any of the others, it must be pointed out that it contains a considerable number of species which are prevalent throughout the Sound, but which in the Bay are to be found only at the inshore dredging stations. This fact, which is not very strikingly illustrated by these figures, will appear much more clearly when the charts portraying the distribution patterns of certain species are scrutinized.

Tables have likewise been prepared listing the "prevalent" species for each type of bottom. The same criterion has here been employed of admitting only those species which have been encountered at one-fourth or more of the number of stations belonging to the group in question.

After considerable thought the following classification of bottoms has been adopted for present purposes, not as being an ideal one, but as being the most simple one possible consistent with a fair regard for accuracy. The only strictly exact classification would recognize as many types of bottom as there are combinations of ingredients listed; but such a classification would be altogether too cumbersome for the purposes of our statistical treatment. We realize that the grouping here employed must result in a quite inadequate characterization of the habitat of many species. A specimen may ostensibly have come from a muddy or a sandy bottom, when, in reality, it was growing attached to a shell or other solid object. We have, nevertheless, included as muddy and sandy those bottoms in which shells were likewise recorded. This has been done for the reason that shells or fragments of these were scarcely ever wholly lacking from the contents of the dredge. Again, certain living mollusks which move freely over the bottom afford support for attached organisms just as well as do dead shells. Surely the presence of such should not suffice to constitute a "shelly" bottom. The same may be said regarding shells occupied by hermit crabs, which abound throughout the entire region, giving support to hydroids, Bryozoa, barnacles, Crepidulæ of several species, and other organisms.

[a] Only 55 per cent of the *Fish Hawk* list for Buzzards Bay were common to the *Fish Hawk* list for Vineyard Sound.

We have accordingly adopted the following classification of bottoms in the ensuing discussion of habitats:

A. "Sand," including bottoms recorded as pure sand, or sand and shells. Bottoms containing stones, gravel, or mud are excluded.

B. "Gravel and stones," including records which list either of these ingredients singly or in combination with one another or with sand. No bottoms containing mud are here included.

C. "Mud," including bottoms recorded as of mud, muddy sand, or sandy mud. Bottoms are here included in which shells are listed, but not those containing gravel or stones.

Certain combinations (e. g., gravel and mud) are excluded from this classification, and records from such stations are not included in the present list. Such cases are, however, relatively very few.

VI. *Species taken at one-fourth (43) or more of the stations dredged on sandy bottoms.*

PORIFERA:
- Cliona celata (49).

HYDROZOA:
- Hydractinia echinata (46).

BRYOZOA:
- Crisia eburnea (74).
- Bugula turrita (107).
- Schizoporella unicornis (63).
- Smittia trispinosa nitida (44).

ASTEROIDEA:
- Asterias forbesi (71).
- Asterias vulgaris (56).

ECHINOIDEA:
- Arbacia punctulata (48).
- Echinarachnius parma (101).

ANNULATA:
- Harmothoë imbricata (72).
- Lepidonotus squamatus (54).
- Nereis pelagica (72).
- Diopatra cuprea (72).
- Hydroides dianthus (61).

CIRRIPEDIA:
- Balanus eburneus (51).

DECAPODA:
- Crago septemspinosus (80).
- Pagurus longicarpus (101).
- Pagurus annulipes (59).
- Libinia emarginata (62).

DECAPODA—Continued.
- Cancer irroratus (92).
- Ovalipes ocellatus (43).

PELECYPODA:
- Anomia simplex (97).
- Pecten gibbus borealis (52).
- Mytilus edulis (113).
- Arca transversa (105).
- Nucula proxima (62).
- Venericardia borealis (49).
- Astarte undata (44).
- Astarte castanea (59).
- Crassinella mactracea (72).
- Cardium pinnulatum (83).
- Callocardia morrhuana (78).
- Tellina tenera (96).
- Ensis directus (84).
- Spisula solidissima (109).
- Clidiophora gouldiana (88).
- Corbula contracta (46).

GASTROPODA:
- Tritia trivittata (142).
- Anachis avara (95).
- Astyris lunata (94).
- Urosalpinx cinereus (46).
- Crepidula fornicata (124).
- Crepidula plana (111).
- Polynices heros (80).
- Polynices triseriata (51).

Of the foregoing 46 species all but 2 appear in one or both of the lists for Vineyard Sound. On the other hand, 8 of the species do not appear in either list for Buzzards Bay, and 14 do not appear in the *Fish Hawk* list for Buzzards Bay. These facts follow directly, of course, from the well-known differences of these two bodies of water in respect to the character of their bottoms.

VII. *Species taken at one-fourth (42) or more of the stations for which bottoms of gravel or stones were recorded.*

PORIFERA:
- Cliona celata (91).

HYDROZOA:
- Eudendrium ramosum (43).
- Hydractinia echinata (43).
- Tubularia crocea (44).
- Thuiaria argentea (47).

ACTINOZOA:
- Astrangia danæ (98).

BRYOZOA:
- Crisia eburnea (97).
- Ætea anguina (50).
- Bugula turrita (99).
- Schizoporella unicornis (96).
- Smittia trispinosa nitida (90).

ASTEROIDEA:
- Henricia sanguinolenta (82).
- Asterias forbesi (83).

ECHINOIDEA:
- Arbacia punctulata (80).

ANNULATA:
- Harmothoë imbricata (80).
- Lepidonotus squamatus (87).
- Nereis pelagica (93).
- Diopatra cuprea (70).
- Pseudopotamilla oculifera (42).
- Hydroides dianthus (118).

CIRRIPEDIA:
- Balanus eburneus (63).

AMPHIPODA:
- Unciola irrorata (46).

DECAPODA:
- Pagurus pollicaris (47).
- Pagurus longicarpus (106).

DECAPODA—Continued.
- Pagurus annulipes (93).
- Libinia emarginata (69).
- Cancer irroratus (71).
- Neopanope texana sayi (64).

PELECYPODA:
- Anomia simplex (83).
- Pecten gibbus borealis (51).
- Mytilus edulis (74).
- Modiolus modiolus (69).
- Arca transversa (81).
- Nucula proxima (69).
- Crassinella mactracea (78).
- Cardium pinnulatum (55).
- Ensis directus (86).
- Cumingia tellinoides (59).
- Spisula solidissima (84).
- Clidiophora gouldiana (66).
- Corbula contracta (55).

AMPHINEURA:
- Chætopleura apiculata (55).

GASTROPODA:
- Tritia trivittata (117).
- Anachis avara (127).
- Astyris lunata (103).
- Urosalpinx cinereus (79).
- Littorina litorea (42).
- Crepidula fornicata (113).
- Crepidula plana (103).
- Polynices heros (59).
- Polynices triseriata (48).

TUNICATA:
- Amaroucium pellucidum (49).
- Amaroucium pellucidum constellatum (61).
- Didemnum lutarium (70).

Of the 54 species in the foregoing list, only 4 are lacking from one or both lists for Vineyard Sound, while 11 are not to be found in either list for Buzzards Bay. Thirty-seven of the species (69 per cent) are common to the list for sandy bottoms.

VIII. *Species taken at one-fourth (28) or more of the stations dredged on muddy bottoms.*

PORIFERA:
- Cliona celata (31).

ACTINOZOA:
- Astrangia danæ (28).

BRYOZOA:
- Crisia eburnea (30).
- Bugula turrita (49).
- Schizoporella unicornis (35).
- Smittia trispinosa nitida (29).

ASTEROIDEA:
- Asterias forbesi (48).

ANNULATA:
- Harmothoë imbricata (35).
- Nephthys incisa (43).
- Diopatra cuprea (54).
- Ninoë nigripes (35).
- Cistenides gouldii (32).
- Clymenella torquata (36).
- Hydroides dianthus (55).

CIRRIPEDIA:
- Balanus eburneus (46).

AMPHIPODA:
- Ptilocheirus pinguis (41).
- Unciola irrorata (32).

DECAPODA:
- Crago septemspinosus (50).
- Pagurus longicarpus (83).
- Pagurus annulipes (44).
- Libinia emarginata (57).
- Cancer irroratus (43).
- Neopanope texana sayi (43).

PELECYPODA:
- Anomia simplex (74).
- Pecten gibbus borealis (57).
- Arca transversa (78).
- Nucula proxima (74).
- Yoldia limatula (66).
- Crassinella mactracea (29).
- Cardium pinnulatum (79).
- Lævicardium mortoni (45).

PELECYPODA—Continued.
- Venus mercenaria (52).
- Callocardia morrhuana (80).
- Tellina tenera (63).
- Macoma tenta (30).
- Ensis directus (64).
- Spisula solidissima (29).
- Mulinia lateralis (60).
- Clidiophora gouldiana (80).

GASTROPODA:
- Busycon canaliculatum (43).
- Tritia trivittata (108).
- Anachis avara (67).
- Astyris lunata (48).
- Eupleura caudata (48).
- Urosalpinx cinereus (29).
- Littorina litorea, shells only (48).
- Crepidula fornicata (84).
- Crepidula plana (74).
- Polynices duplicata (35).
- Polynices triseriata (41).

Of the 50 species comprised in the above list only two[a] are absent from that representing the prevailing species dredged by the *Fish Hawk* in Buzzards Bay; while only 7 species in the latter list are lacking from that for the muddy bottoms. The two groups of species are thus not far from identical. On the other hand, 13 of those in the list for muddy bottoms do not appear in either table for Vineyard Sound. Thirty-three of the species (66 per cent) are common to the list for sandy bottoms, while 34 species (68 per cent) are common to that for bottoms of gravel and stones.

Comparing the lists for the three types of bottom, we find 13 species which appear only in that for bottoms of stones and gravel, an equal number which appear only in the list for muddy bottoms, while 6 are peculiar to the list for sandy bottoms. Of the 13 prevalent mud-dwelling forms, all but 1 are annelids or mollusks. Of the 13 species peculiar to the list for gravelly and stony bottoms, 3 are hydroids and 3 are ascidians, the remainder being distributed through various phyla. The number of forms which are restricted to our list of prevalent species for bottoms of pure sand (free from mud on the one hand, and from stones and gravel on the other) is a very short one. This is due to the fact that the great majority of sand-dwelling species are not deterred by the presence of a certain proportion of stones and gravel, while many of them are equally at home in sand which is somewhat muddy. In our classification, however, such bottoms have been included under "gravel and stones" and "mud," respectively. At least two of the species listed are, nevertheless, pretty definitely restricted to bottoms of pure sand. These are the "lady crab" (*Ovalipes ocellatus*) and the "sand dollar" (*Echinarachnius parma*).

In any consideration of such tables as the foregoing, it must be borne in mind that the fact of a species being restricted to one or another of the tables does not imply that it is absent from the other types of bottom, or subdivisions of the region. Indeed, it

[a] These two are contained in the *Phalarope* Buzzards Bay list.

sometimes happens that the species is recorded from an *absolutely greater* number of stations of another group than that for which it is here listed. Again, the caution must be repeated (cf. p. 31, 33) that in the field a specimen was frequently recorded from a certain type of bottom when it seems probable that the dredge, at the moment of taking it, was passing over a quite different type of bottom. In many parts of our local sea floor several distinct varieties of bottom may be encountered within a quite limited area.

Nevertheless, we believe that real and important facts of ecology are revealed by such tabulations as the foregoing, even though these may not in themselves present a complete picture. For concrete illustrations of the assemblage of organisms which may actually occur together on a given bottom, or at least within the area traversed during a single dredge haul, the reader is referred to the tables on pages 58 to 62.

Thus far the lists of "prevailing" species for one or another group of stations have had no reference to the temperature factor. It has been thought desirable, however, to present a list of those species which have been taken at one-fourth or more of the stations within the cold-water area of the region, i. e., the area throughout which the water temperature in summer has been found to be considerably lower than elsewhere. For this purpose the *Fish Hawk* stations (and these only) were chosen, lying, in Vineyard Sound, beyond (southwest of) a line drawn from Robinsons Hole to Kopeecon Point, and in Buzzards Bay below a line drawn from Barneys Joy Point to Penikese Island. One hundred and one stations were included in this area.

IX. *Species taken at one-fourth (25) or more of the stations in the colder waters adjacent to the open ocean.*

HYDROZOA:
- Hydractinia echinata (34).
- *Obelia geniculata* (27).
- *Halecium halecinum* (27).

BRYOZOA:
- Crisia eburnea (43).
- Ætea anguina (25).
- Bugula turrita (70).
- Schizoporella unicornis (46).
- Cellepora americana (30).

ASTEROIDEA:
- Asterias forbesi (51).
- Asterias vulgaris (58).

ECHINOIDEA:
- Arbacia punctulata (25).
- Echinarachnius parma (70).

ANNULATA:
- Harmothoë imbricata (39).
- Nereis pelagica (35).
- Diopatra cuprea (43).

CIRRIPEDIA:
- Balanus eburneus (37).

AMPHIPODA:
- Unciola irrorata (27).
- *Æginella longicornis* (35).

ISOPODA:
- Idothea phosphorea (26).

DECAPODA:
- Crago septemspinosus (49).
- *Pagurus acadianus* (39).
- Pagurus longicarpus (59).
- Libinia emarginata (37).
- Cancer irroratus (75).
- *Ovalipes ocellatus* (41).

PELECYPODA:
- Anomia simplex (54).
- *Pecten magellanicus* (26).
- Mytilus edulis (82).
- Modiolus modiolus (25).
- Arca transversa (60).
- Nucula proxima (30).
- Venericardia borealis (63).
- *Astarte undata* (51).
- Astarte castanea (44).
- Crassinella mactracea (41).
- Cardium pinnulatum (55).
- Callocardia morrhuana (63).
- Tellina tenera (55).
- Ensis directus (30).
- Spisula solidissima (72).

PELECYPODA—Continued.
- Clidiophora gouldiana (58).
- Corbula contracta (33).

GASTROPODA:
- Tritia trivittata (88).
- Anachis avara (40).
- Astyris lunata (48).
- Crepidula fornicata (65).
- Crepidula plana (62).

GASTROPODA—Continued.
- Polynices heros (60).
- Polynices triseriata (35).

CEPHALOPODA:
- Loligo pealii (37).

PISCES:
- *Raja erinacea* (31).
- *Lophopsetta maculata* (31).

In the foregoing table it will be noted that only nine species (those italicized) have not already appeared in one or more of the lists for Vineyard Sound or Buzzards Bay. And not all these nine are species whose distribution has been determined by temperature; for example, *Ovalipes*, *Raja*, and *Lophopsetta* (see below). Such a list is thus ill adapted to displaying the peculiarities of the fauna occupying the colder waters of the region. But an examination of the distribution charts reveals the presence of a considerable number of species which are chiefly or wholly restricted to the colder waters under consideration. A list of these has been given below, along with the recorded range of each upon the North American coast. It will be seen that in 15 out of 20 cases the range of these species is predominantly northward,[a] some of them, indeed, being near their southern limit of distribution. The presence of three of the others (*Ovalipes ocellatus*, *Molgula arenata*, and *Lophopsetta maculata*) is sufficiently explained by the nature of the bottom at the western end of the Sound, since these are characteristic sand-dwelling species.[b]

X. *Species restricted to, or at least occurring predominantly in, the colder waters of Vineyard Sound and Buzzards Bay.* (Limited to species occurring at 10 or more stations.)

CŒLENTERATA:
- Eudendrium dispar.—Vineyard Sound to Bay of Fundy. (N.)
- Alcyonium carneum.—Rhode Island to Gulf of St. Lawrence. (N.)

ECHINODERMATA:
- Asterias vulgaris.—Labrador to Cape Hatteras, but not littoral south of Woods Hole. (N.)
- Strongylocentrotus droebachiensis.—Circumpolar, south to New Jersey. (N.)

CRUSTACEA:
- Calliopius læviusculus.—Narragansett Bay to Greenland. (N.)
- Pontogenia inermis.—Vineyard Sound to Arctic Ocean. (N.)
- Pagurus acadianus.—Grand Bank to mouth of Chesapeake Bay. (N.)
- Ovalipes ocellatus.—Cape Cod to Gulf of Mexico. (S.)

MOLLUSCA:
- Pecten magellanicus.—Labrador to Cape Hatteras. (N.)
- Modiolaria nigra.—Arctic seas to Cape Hatteras. (N.)
- Crenella glandula.—Arctic seas to Cape Hatteras. (N.)
- Venericardia borealis.—Arctic seas to off Cape Hatteras. (N.)
- Astarte undata.—Gulf of St. Lawrence to Cape Hatteras. (N. and S.)
- Cyclas islandica.—Arctic Ocean to Cape Hatteras [in deep water]. (N.)
- Thracia conradi.—Labrador to Cape Hatteras. (N.)
- Buccinum undatum.—Arctic seas to Charleston Harbor. (N.)
- Crucibulum striatum.—Nova Scotia to Florida Keys. (S.)

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[a] See p. 184 for standard employed in grouping species as "northward ranging" or "southward ranging."

[b] *Ovalipes* and *Lophopsetta*, indeed, are known to occur on sand flats at various points throughout the region, irrespective of temperature.

TUNICATA:

Molgula arenata.—New Haven to Nantucket. (?)

Eugyra glutinans. (N.)

PISCES:

Lophopsetta maculata.—Casco Bay to South Carolina. (S.)

Passing reference should likewise be made to certain species which were taken at less than 10 stations, and which, therefore, are not included among those charted. Some of these species are *Polymastia robusta* (a sponge), *Tealia crassicornis* (an anemone), *Ophiopholis aculeata* (an ophiuroid), *Thyone unisemita* (a holothurian), *Pandalus leptocerus* (a shrimp), and *Hyas coarctatus* (a crab). Each of these has been recorded more than once at the open ends of the Bay and the Sound, but never, so far as we know, in the more inclosed waters.

For the sake of comparison with the foregoing, a list is presented herewith comprising those species which were taken at two or more of the seven regular Survey stations at Crab Ledge, off Chatham. Here, as stated above (p. 51), the bottom temperature of the water in summer is considerably lower than at the western end of Vineyard Sound, and many degrees lower than in the greater part of the area dredged by us.

XI.—*Species dredged at 2 or more of the 7 Survey stations at Crab Ledge.*

FORAMINIFERA:

Discorbina rosacea (3).

PORIFERA:

Polymastia robusta (5).
Halichondria panicea (5).
Desmacidon palmata (6).

HYDROZOA:

Eudendrium ramosum (2).
Hydractinia echinata (7).
Tubularia tenella (3).
Tubularia crocea (6).
Sertularella tricuspidata (3).

ACTINOZOA:

Metridium dianthus (5).
Alcyonium carneum (3).

BRYOZOA:

(Not listed for these stations individually.)

ASTEROIDEA:

Henricia sanguinolenta (5).
Asterias austera (6).
Asterias vulgaris (7).

OPHIUROIDEA:

Ophiopholis aculeata (6).

ECHINOIDEA:

Strongylocentrotus drobachiensis (7).

ANNULATA:

Harmothoë imbricata (3).
Nereis pelagica (5).
Nothria conchylegia (2).
Thelepus cincinnatus (6).
Pseudopotamilla oculifera (4).
Chætinopoma greenlandica (2).
Filograna implexa (5).

AMPHIPODA:

Ericthonius rubricornis (2).

DECAPODA:

Pagurus acadianus (6).
Pagurus kroyeri (4).
Hyas coarctatus (5).
Cancer irroratus (3).

PELECYPODA:

Anomia simplex (2).
Anomia aculeata (4).
Pecten magellanicus (4).
Mytilus edulis (2).
Modiolus modiolus (6).
Modiolaria lævigata (5).
Venericardia borealis (3).
Astarte undata (3).
Cyclas islandica (2).
Spisula solidissima (4).
Thracia septentrionalis (2).
Saxicava arctica (4).
Cyrtodaria siliqua (3).

GASTROPODA:

Coryphella salmonacea (3).
Buccinum undatum (6).
Chrysodomus decemcostatus (2).
Tritonofusus stimpsoni (3).
Boreoscala grœnlandica (5).
Polynices triseriata (2).
Velutina zonata (2).

TUNICATA:

Halocynthia echinata (2).
Amaroucium stellatum (3).
Didemnum lutarium (6).

Among the foregoing species, the following have been already mentioned as restricted, in Vineyard Sound and Buzzards Bay, chiefly or wholly to the colder waters adjoining the open ocean: *Polymastia robusta, Alcyonium carneum, Asterias vulgaris, Ophiopholis aculeata, Strongylocentrotus droebachiensis, Pagurus acadianus, Hyas coarctatus, Pecten magellanicus, Venericardia borealis, Astarte undata, Cyclas islandica, Buccinum undatum.* In reality the number of those species which are common to Crab Ledge and the colder parts of Vineyard Sound and Buzzards Bay, but which are not encountered elsewhere in local waters, is considerably greater than this brief list would imply.

A contrary condition is found in the case of certain species which are of general distribution throughout Vineyard Sound, and in many cases throughout Buzzards Bay as well, but which are nearly or quite absent from just those waters to which the foregoing species seem best adapted. The following is a partial list of such, based upon an examination of the distribution charts.

XII. *Species which appear to be scarce or lacking in the colder waters of Vineyard Sound and Buzzards Bay.* (Limited to species which occur at 10 or more stations of the Survey.)

COELENTERATA:
- Astrangia danæ.—Florida to Cape Cod. (S.)
- Thuiaria argentea.—North Polar regions to Maryland. (N.)

ECHINODERMATA:
- Arbacia punctulata.—Nantucket Shoals to Yucatan. (S.)

ANNULATA:
- Lumbrineris hebes.—Casco Bay to New Jersey. (N. and S.)
- Hydroides dianthus.—Massachusetts Bay to Charleston, South Carolina. (S.)

CRUSTACEA:
- Batea secunda.—Local. (?)
- Pagurus annulipes.—Nantucket Sound to Florida. (S.)
- Pelia mutica.—Vineyard Sound to Florida. (S.)
- Neopanope texana sayi.—Cape Cod to Florida. (S.)

PYCNOGONIDA:
- Anoplodactylus lentus.—Long Island Sound, Vineyard Sound, Eastport, 1 record. (?)
- Tanystylum orbiculare.—Marthas Vineyard to Virginia. (S.)

MOLLUSCA:
- Vermicularia spirata.—New England to West Indies. (S).
- Chætopleura apiculata.—Cape Cod to West Indies. (S).

TUNICATA:
- Perophora viridis.—Woods Hole to Beaufort, N. C., and Bermuda. (S.)
- Styela partita.—Massachusetts Bay to North Carolina. (S.)
- Amaroucium stellatum.—Cape Cod to North Carolina.? (S.)
- Amaroucium pellucidum.—Vineyard Sound to North Carolina. (S.)

It will be noted that only one of these species has a predominantly northern range upon our coast. It is also to be pointed out that, with a single exception (*Amaroucium stellatum*), none of these species have been recorded by us from Crab Ledge.[a] We do not wish to lay undue emphasis upon such correspondences, however. It is likely that some of these species actually occur at Crab Ledge, in spite of our failure to find them. It is likewise probable for some of them, at least, that their distribution in

[a] I. e., not *once*. We do not here refer to the above table of species taken two or more times.

Vineyard Sound is not determined by temperature, but by the character of the bottom. Nevertheless, after making these allowances, the significance of the facts discussed upon the last few pages can scarcely be doubted.

4. THE AVERAGE YIELD OF THE DREDGE HAULS.

Another method of portraying synoptically the general facies of our local fauna, as revealed by the dredge, is to present the average composition of the dredge hauls. This we have computed for the Survey as a whole, and for the separate groups of stations which have been distinguished above; for the animal kingdom as a whole, and for its main subdivisions. In the following tables certain groups which were represented very sparingly in our dredgings, or which were not looked for systematically, and certain others which do not properly belong to the benthos have been omitted.

I. *Average number of genera and species of animals taken per dredge haul.*

	Genera.	Species.
Survey as a whole (458 stations)	34.3	37.0
Fish Hawk, Vineyard Sound (218 stations)	33.7	36.5
Fish Hawk, Buzzards Bay (66 stations)	36.3	38.7
Fish Hawk, Crab Ledge (7 stations)	37.0	39.7
Phalarope and Blue Wing, Vineyard Sound (77 stations)	32.1	35.2
Phalarope, Buzzards Bay (90 stations)	36.0	38.5

While there is a rather surprising uniformity amongst these figures, it will be noted that the average number of species is slightly greater for the *Fish Hawk* than for the *Phalarope* stations; likewise that it is greater for Buzzards Bay than for Vineyard Sound, and greatest of all for Crab Ledge. It is of interest, likewise, that the average number of genera per dredge haul is nearly equal to that of the species. This point will be discussed later.

II. *Average number of genera and species for the 458 regular stations of the Survey, showing representation of each group of animals.*

Group.	Genera.	Species.	Group.	Genera.	Species.
Porifera	.7	.7	Cirripedia	.4	.4
Hydrozoa	1.4	1.4	Decapoda	2.8	3.5
Actinozoa	.4	.4	Amphipoda	1.6	1.6
Nemertinea	.04	.05	Isopoda	.4	.4
Bryozoa	2.8	2.9	Pycnogonida	.1	.1
Asteroidea	.8	1.0	Pelecypoda	8.9	9.2
Ophiuroidea	.1	.1	Amphineura	.2	.2
Echinoidea	.8	.8	Gastropoda	5.9	6.8
Holothuroidea	.03	.03	Cephalopoda	.2	.2
Annulata	4.3	4.3	Tunicata	.9	1.1
Sipunculida	.05	.05	Pisces	1.1	1.1

In the foregoing table, it is nearly certain that the figures for certain groups, especially, perhaps, for the Porifera, do not fairly represent the number of these forms. For this reason, indeed, the Foraminifera have been omitted altogether. As stated in another section (p. 91), the Foraminifera were looked for systematically during one season only, while the Porifera at no time received adequate attention.

III. *Average number of species per dredge haul for the two vessels and the two bodies of water considered separately.*

Group.	Fish Hawk stations.			Phalarope and Blue Wing stations.	
	Vineyard Sound (218).	Buzzards Bay (66).	Crab Ledge (7).	Vineyard Sound (77).	Buzzards Bay (90).
Porifera	0.6	0.8	2.3	0.9	0.7
Hydrozoa	2.0	.7	3.9	1.1	.8
Actinozoa	.5	.5	1.1	.4	.4
Nemertinea	.01	.2	....	.01	.02
Bryozoa	3.4	2.7	(a)	3.0	2.0
Asteroidea	1.2	.6	3.0	1.0	.6
Ophiuroidea	.1	.1	.9	.1	.07
Echinoidea	1.2	.2	1.0	.6	.4
Holothuoridea	.01	.09	....	.04	.01
Annulata	3.5	6.2	5.9	4.6	4.6
Sipunculida	.01	.02	....	.01	.2
Cirripedia	.4	.5	.3	.2	.3
Amphipoda	1.8	1.3	.7	1.9	1.1
Isopoda	.3	.09	....	.8	.3
Decapoda	3.8	3.4	3.3	3.2	3.2
Pycnogonida	.2	.02	....	.1	....
Pelecypoda	8.2	11.5	7.4	7.5	11.6
Amphineura	.2	.2	....	.2	.3
Gastropoda	5.4	7.4	4.7	7.2	9.7
Cephalopoda	.3	.3	....	.06	....
Tunicata	1.3	.4	3.3	1.6	.7
Pisces	1.5	1.3	.4	.6	.3

[a] The Crab Ledge Bryozoa have not been listed by stations.

In a similar way we have represented the wealth in species of each of the types of bottom which have been distinguished (see p. 70).

IV. *Average number of genera and species per dredge haul for the three types of bottom.*

	Genera.	Species.
Sand (170)	33.6	36.5
Gravel and stones (167)	35.3	38.0
Mud (112)	34.8	37.2

While there is here, likewise, a rather surprising uniformity among the figures, it is to be noted that the number of species is greatest for the stony bottoms and least for the sandy ones.

V. *Average number of species per dredge haul, showing the representation of the various groups of animals on each type of bottom.*

Group.	Sand.	Gravel and stones.	Mud.
Porifera	0.5	1.0	0.5
Hydrozoa	1.5	1.8	.8
Actinozoa	.3	.7	.3
Nemertinea	.02	.01	.1
Bryozoa	2.8	3.7	2.0
Asteroidea	.9	1.3	.6
Ophiuroidea	.08	.1	.2
Echinoidea	1.0	.8	.4
Holothuroidea	.02	.01	.05
Annulata	3.4	4.7	5.2
Sipunculida	.05	.03	.1
Cirripedia	.3	.4	.4
Amphipoda	1.6	1.6	1.6
Isopoda	.5	.4	.2
Decapoda	3.5	3.5	3.6
Pycnogonida	.05	.2	.03
Pelecypoda	9.8	7.7	11.0
Amphineura	.1	.3	.1
Gastropoda	6.5	6.7	7.8
Tunicata	.9	1.9	.4
Pisces	1.4	.7	1.2

To what degree such figures as the foregoing, giving the average number of species per dredge haul, represent the actual wealth in species of the various subdivisions of our local sea bottom can not be stated with certainty. Whether, for example, the greater number of species per dredge haul found in Buzzards Bay denotes an actually greater number of species per unit area of sea floor, is not self-evident. It is plain that the dredge must cut more deeply into a bottom of soft mud than into one of hard sand or gravel, and that therefore a larger proportion of burrowing organisms will be obtained in the former. It seems quite possible, therefore, that the excess in favor of Buzzards Bay has been exaggerated, or that it does not exist at all.

Now, an inspection of table VI, showing the total number of species taken at each of the five groups of stations, reveals the fact that the number of species taken by the *Fish Hawk* in Vineyard Sound is about 25 per cent greater than that taken in Buzzards Bay. But it must likewise be borne in mind that the number of *Fish Hawk* stations in Vineyard Sound was over three times as great as that in Buzzards Bay, thus rendering probable the capture of a larger number of the less common species. In fact, it will be noticed that the figures expressing the total number of species for each of these groups of stations may be arranged in the same order as those expressing the number of stations in each group.[a] We nevertheless think it likely, in view of all our data, that the actual number of species inhabiting Vineyard Sound is greater than that inhabiting Buzzards Bay. This is probably due to the fact that the bottom of the former

[a] That the number of species in each case is in no sense proportional to the number of stations is, however, quite plain.

presents a greater diversity of conditions than that of the latter, rendering it a fit habitation for a greater variety of life. Such a view is in no way inconsistent with the supposition that the number of species *per unit area* is as great, or even greater, in Buzzards Bay. This matter will be referred to later.

VI. NUMBER OF SPECIES TAKEN ONE OR MORE TIMES DURING THE DREDGING.[a]

Group.	Vineyard Sound.			Buzzards Bay.			Crab ledge.
	Fish Hawk.	Phalarope.	Total.	Fish Hawk.	Phalarope.	Total.	
Foraminifera	17	1	18	....	19	19	1
Porifera	9	8	10	5	7	9	3
Hydrozoa	14	12	16	7	9	9	11
Actinozoa	4	3	4	2	1	2	2
Nemertinea	2	....	2	4	2	6	....
Bryozoa	29	26	32	13	18	21	(b)
Asteroidea	3	3	3	3	3	3	6
Ophiuroidea	2	1	2	2	2	3	1
Echinoidea	3	3	3	3	3	3	1
Holothuroidea	2	1	2	2	1	2	....
Annulata	51	41	60	38	38	48	17
Sipunculida	1	1	2	1	2	3	....
Ostracoda	20	....	20	....	5	5	....
Cirripedia	2	1	2	1	1	1	2
Amphipoda	25	23	29	11	18	20	5
Isopoda	6	6	8	2	9	9	....
Cumacea	1	1	2	....	....	....	....
Schizopoda	1(+?)	1(+?)	1(+?)	....	1(+?)	1(+?)	1
Decapoda	20	13	21	11	15	17	9
Pycnogonida	2	3	3	1	....	1	....
Xiphosura	1	....	1	1	1	1	....
Pelecypoda	49	36	49	38	40	43	23
Amphineura	1	1	1	1	2	2	....
Gastropoda	38	34	48	30	42	47	13
Cephalopoda	1	....	1	1	....	1	....
Tunicata	16	11	17	4	8	9	8
Pisces	25	13	27	13	8	15	3
Total	345	243	384	194	255	300	[b] 100

[a] This table relates to the "regular" stations only. Species of uncertain identity have been included along with the determined ones in these computations.

[b] Bryozoa not included.

5. EXPLANATION OF THE FAUNAL CATALOGUE.

Part III of the present work consists of a catalogue or annotated list of the fauna of the Woods Hole region. The extent of territory comprised within the limits of the "Woods Hole Region," as here conceived, has already been indicated in chapter I, of the present volume, where we have likewise discussed the sources of information upon which the present catalogue is based.

It is true that an insignificant proportion, numerically considered, of those who frequent the laboratories at Woods Hole at the present time are interested primarily in systematic zoology or botany. But every working biologist, whatever his specialty,

deals with one or more species of animals or plants, which constitute, or at least furnish him with, the raw materials for his research. Thus, it is of advantage to all that a carefully prepared list of these organisms should be published, if regarded merely as a catalogue of available material. And it will, we trust, be of additional advantage to have at hand a single reference work which shall embody the nomenclature most recently adopted for these species by some of our most competent systematic experts. Confusion will, we think, be minimized by the existence of some standard, even though this standard may be a fallible one.

In the present catalogue we are offering, however, far more than a mere list of species. We have gathered together all available data regarding distribution within local waters, seasonal occurrence, reproduction, etc., and have added various ecological notes, where these have seemed appropriate. It is our hope that these data may be of service to those who are in search of material for embryological or other studies. And we further hope that the decidedly meager notes which we offer may constitute a nucleus for future growth in this direction.

It must be emphasized that we do not in any sense guarantee the trustworthiness of all the records herein contained. A large proportion of them have been included wholly upon the authority of others, whose names are mentioned in the text. Many species are included, indeed, which have never been seen either by the present writers or by the specialists who have collaborated with us. While such citations are, in most cases, based upon the statements of recognized authorities, it is more than possible that in some cases they rest upon errors of observation or of identification. But it would have been a very difficult task to cull out such mistakes, and we have therefore included all records based upon the statements of persons believed to be trustworthy, unless we happen to have definite evidence that these statements were erroneous. The mere failure of subsequent observers to find a species which had been included in one of the earlier lists is not to be regarded as decisive evidence of an error, in view of the known instances of change in the population of our local waters.

Due credit has been given in a large proportion of cases to the authority for each statement made, the name of this person being inserted at the close of the citation. The person cited is responsible only for so much of the statement as immediately precedes his name. Independent citations are in nearly all cases separated by periods. In many instances the statement cited has never been published by the individual referred to, but has been communicated to one of the present authors orally or recorded in manuscript. Where no authority has been indicated for a given statement we mean either (1) that the present authors are themselves responsible for the observation, or (2) that the fact stated is a matter of common knowledge to a large number of observers, or (3), in certain self-evident cases, that the bibliographic reference indicates the authority for the statement.

With most groups of animals, as already stated, a certain proportion of the specimens collected were referred to specialists for identification. Since the value of a record depends, in great measure, upon the trustworthiness of the identification, we have indicated in a large number of cases, the authority for the latter. The symbols (* and the like) denote that specimens from the localities so designated have been identified by persons mentioned in a foot note at the commencement of the list. In the case of those organisms specimens of which were invariably referred to specialists, symbols

have been omitted in connection with the records, the general acknowledgments in chapter IV being regarded as sufficient. In other cases, failure to mention the authority for a determination implies that the specimen was identified by one of the present authors. This is true of the great majority of readily recognizable species belonging to various phyla.

It must be borne in mind that the number of specimens recorded for a given station represents, in many cases, the number saved and listed, rather than the number actually brought in by the dredge. For many animals, especially minute ones, the former figure may give no adequate idea of the relative abundance of the species in a given dredge haul.

The bibliographic references under each species will be found to be very limited in number, and to include, with a few exceptions, only those works which mention the occurrence of this species within the limits of the region here under consideration. One work has been regularly included, however, even in cases where no mention was made of Woods Hole or vicinity by the authors. This is the "Report upon the Invertebrate Animals of Vineyard Sound" by Verrill and Smith (1873). Likewise, in the list of mollusks, we have regularly included page references to Binney's edition of Gould's "Report on the Invertebrata of Massachusetts," and for the fishes references to Jordan and Evermann's "Fishes of North and Middle America." It has not been thought worth while to cite the first description of each species nor even to refer to any description or figure. To have included these would doubtless have added considerably to the usefulness of this report, but we need only remind the reader that the search for such few bibliographic citations as are here offered required many months of thoroughly uninspiring labor. In many cases reference to original descriptions and figures may be found in one or another of the works here cited. Bibliographic lists, limited almost wholly to the works referred to in connection with the separate species, have been appended to the zoological and botanical sections of the catalogue.

In order to facilitate the finding of a species which has been listed by a name unfamiliar to the reader, a certain number of synonyms have been included in connection with the bibliographic references. Only those names are included, however, by which the species in question has been designated in the various works relating to our local fauna. The synonyms here listed are all included in the systematic index. This will probably render possible the finding of a desired species in a large proportion of cases.

As respects classification and nomenclature, we have found it expedient, and indeed unavoidable, to follow within each group some one authority, this authority being, in most cases, the same person who has been responsible for the identification of our species. Only thus has it been possible to avoid a quite interminable examination of the literature on our part. This precedure has frequently led to our being obliged to substitute quite unfamiliar names for ones long current among American biologists, and to our listing under separate genera species which, to everyone but the taxonomist, are scarcely distinguishable from one another as species. No one could deplore more than we do the necessity for such changes, and this regret is the keener because of the confidence we feel that many of these names are not the ones that will ultimately stand.

Several years' experience in the preparation of our faunal catalogue has brought home to us in a forcible way some of the most exasperating of the evils relating to

zoological nomenclature. Indeed, it is upon the authors of works like this, who make extensive use of taxonomic names, while having very little share in their creation or transmutation, that these evils perhaps fall most heavily.

On the other hand, we realize that there are many sides to this perplexing question, and that many of the generic and specific names in current use among Woods Hole biologists are entirely unjustified, as judged by any standard except local usage. Those who revolt because the long-cherished name of a favorite species has been replaced by a totally unfamiliar one, must be reminded that this is not always due to the caprice of some perverse "species monger." Nor are these changes in all cases due to the discovery that some long-forgotten name has "priority." There are several other (legitimate) reasons for changing the name of a species, of which mention may be made of two. (1) Careful comparison may reveal the fact that two supposedly distinct species dwelling in different parts of the world are, in reality, identical. One or the other name must be given up. Thus, we have over and over again been obliged to abandon names given by earlier American zoologists to species found upon the shores of the New World. We need only mention the "*Spongia sulphurea*" of Desor (=*Cliona celata* Grant), the "*Hydractinia polyclina*" of Agassiz (now believed to be identical with *H. echinata* Fleming), or the "*Ascidia tenella*" of Stimpson (=*Ciona intestinalis* (Linnæus)). In such cases, the changes may at first jar upon our nerves, but they must be accepted. (2) More complete knowledge of a species may show that its systematic position has at first been misunderstood. Here, as in the first case, we are not dealing with rules of nomenclature, but with facts. If the facts demand it, the species must be assigned to another genus. The most severe critics of our systematic brethren would hardly doubt the wisdom of removing the toadfish from the genus *Gadus*, to which it had been assigned by Linnæus; nor the expediency of so restricting the genus *Nautilus* as to exclude the spiral Foraminifera!

Many cases are sure to arise, however, when the mere *user* of zoological names—and to this class belong the great majority of present day zoologists—may well query whether the more refined grouping of species could not better be carried out within the limits of the genus itself. The latter procedure has the advantage of leaving the generic name (and therefore the full name of the species) unaltered. It is not so much for the changing of their conceptions of relationship that systematic zoologists are criticised so sharply as for their persistent changing of the names which we are all obliged to use and which we must learn anew as often as substitutes are offered by accredited authorities. This criticism derives particular force from the fact that there is no general agreement as to how inclusive a division the genus shall be. It is safe to say that at the present time the "genera" of some groups of the animal kingdom are as inclusive as the "families" of certain others, while the "genera" of these latter may correspond more nearly to the "subgenera" of the first.

It will be understood without further explanation why we have not adopted the practice, current among certain systematists, of including the subgeneric name, in parenthesis, as an integral part of the name of a species. The subgenus is of interest only to the systematist, who may readily find it by reference to the appropriate systematic treatise. The name of the species is complete without it, and the biologist at large should not be burdened by having to learn trinomials of this sort.

6. SYNOPSIS OF THE FAUNAL CATALOGUE.

A table has been prepared showing the total number of families, genera, and species comprised in our annotated list, grouped according to the larger divisions of the animal kingdom; likewise the number which have been recorded during our dredging operations and the number of those encountered which had not previously been listed for local waters. In this table species have been entered as doubtful, either because the determination of the species was made with doubt, or because of uncertainty whether the specimens taken really came from within the region here considered.[a]

In the "undetermined" column are included species which have been referred to a genus but not to a species, provided only that no determined member of the same genus has also been listed with which the species in question may be identical.

Species have been listed as "taken by dredge" which were recorded either from the regular dredging stations of the survey or from any of our supplementary stations, numbered or unnumbered.

Species have been listed as "added to fauna of region" when it is believed that their local occurrence was recorded for the first time, either as a result of the survey dredging or of the other collecting operations which were carried on during these same years by members of the laboratory staff or by investigators who have cooperated in the work. In many cases, it is true, these additions to our local fauna have been announced in other publications, but their inclusion here seems none the less justifiable.

SYNOPTIC TABLE OF SPECIES COMPRISED IN ANNOTATED LIST.

Groups of organisms.	Number of families represented.	Number of genera.	Number of species (total).		Species taken by dredge.	Species added to fauna of region.
			Determined.	Undetermined.		
Protozoa	(?)	75	99	5	23	28
Porifera	8	15	12(+2?)	5	11(+3?)	3(+1?)
Hydrozoa	34	76(+3?)	132(+8?)	....	28(+1?)	6(+2?)
Scyphozoa	4(+1?)	5(+1?)	5(+1?)	....	....	....
Actinozoa	9(+2?)	10(+3?)	14(+3?)	....	4(+2?)	2
Ctenophora	7	7	8	....	....	....
Turbellaria[b]	19	31	40(+1?)	....	....	....
Trematoda	(?)	15	52(+2?)	2	....	....
Cestoda	(?)	29	71	3	....	....
Nemertinea	9	13	25(+1?)	....	6	....
Nemathelminthes	(?)	12	33(+5?)	....	....	....
Chætognatha	1	1	1	1	....	....
Dinophilea	1	1	3	....	....	....
Bryozoa	21	36(+1?)	76(+5?)	....	67(+1?)	44(+1?)
Asteroidea	3	3	6	....	6	....
Ophiuroidea	4	6	6	....	5	....
Echinoidea	3	4	4	....	3	....
Holothuroidea	3	5	8(+1?)	....	4	....
Polychæta	35	98	133(+6?)	4	78(+4?)	7(+6?)
Oligochæta	4	8	11	....	....	....
Hirudinea	1	3	4	....	1	....
Sipunculida	1	2	3	....	3	....

[a] Certain species only recorded from beyond the 20-fathom line, and thus perhaps somewhat extralimital, are also here listed.
[b] The species added by von Graff (1911) have been included in this table. Von Graff's families are likewise included in the computation.

SYNOPTIC TABLE OF SPECIES COMPRISED IN ANNOTATED LIST—Continued.

Groups of organisms.	Number of families represented.	Number of genera.	Number of species (total).		Species taken by dredge.	Species added to fauna of region.
			Determined.	Undetermined.		
Phyllopoda	1(+1?)	2(+1?)	2(+1?)			2
Ostracoda	3	11	26		21	26
Copepoda (free)	13(+1?)	22(+1?)	25(+1?)			14
Copepoda (parasitic)	8	32	58(+2?)			
Cirripedia	4	6	15(+2?)		2(+1?)	2
Amphipoda	22(+2?)	54(+5?)	71(+3?)	3	35	9
Isopoda	11(+1?)	20(+2?)	25(+3?)		10	1
Cumacea	3	6	8(+2?)		1	1
Stomatopoda	1	2	3			
Schizopoda	2	4	5		1(+?)	1(+?)
Decapoda	20	37(+2?)	51(+4?)		27(+2?)	4
Xiphosura	1	1	1		1	
Pycnogonida	5(+1?)	5(+1?)	5(+1?)		4	2
Arachnida	1	1	1			
Insecta	(?)	25	16	13		?
Pelecypoda	31	48(+1?)	70(+6?)		57	6
Amphineura	1	2	2		2	
Gastropoda	43	81	129(+9?)	1	65(+2?)	17(+?)
Cephalopoda	3	4	4		1	
Enteropneusta	1	1	1			
Tunicata	10	18	22(+5?)	5	14(+6?)	3(+5?)
Pisces	99	188(+2?)	247(+5?)	1	30	6(+1?)
Reptilia	4	5	5			
Aves	12	44	75			
Mammalia	6	11(+2?)	12(+3?)			
Total	472(+?)	1,085(+25?)	1,625(+82?)	43	510(+22?)	184(+?)

7. COMPARISON OF THE WOODS HOLE CATALOGUE WITH CERTAIN OTHERS.

While it is no part of our present plan to enter into a historical discussion of the progress which has been made in cataloguing the marine fauna and flora of other parts of the world, it has seemed worth while to compare our own annotated list with certain others, both American and European. Accordingly, we have presented in parallel columns the number of species belonging to each group which have been listed for Vineyard Sound and adjacent waters by Verrill and Smith (1873); for eastern Canada by Whiteaves (1901); for the vicinity of Plymouth, England, by the Marine Biological Association (1904); for the Irish Sea by Herdman and his colleagues (1896); and for the Gulf of Trieste by Graeffe (1880–1903).

The work of A. E. Verrill and S. I. Smith, which appeared in the first report of the United States Commissioner of Fish and Fisheries, was the most ambitious attempt which had yet been made to catalogue the fauna of any section of our coast. While nominally a "Report upon the Invertebrate Fauna of Vineyard Sound and the Adjacent Waters," and based primarily upon the earliest dredging operations of the United States Fish Commission, the scope of this work extended to the whole southern shore of New England, and incidentally to more distant points. The report is divided into two chief

sections, the first of which comprises a discussion of the fauna, according to particular habitats and types of bottom (e. g., "rocky shores of the bays and sounds," "muddy bottoms off the open coast," etc.), the second being constituted by the catalogue or annotated list, together with a considerable number of descriptions and figures. The former section contains an extensive mine of ecological facts of interest and value, and despite the somewhat loose and desultory method of treatment the work will remain a classic in American marine ecology. In all, over 650 species were listed by these authors, a considerable number of these being described as new to science. The range of each species, so far as known, was stated, along with its bathymetric distribution and other facts in its natural history.

In preparing our own catalogue of the fauna, we have incorporated all the species recorded from the "Report upon the Invertebrate Animals of Vineyard Sound," excepting such as are plainly extralimital, or such as are believed to have been wrongly identified. A detailed comparison of the two lists furnishes some evidence of a certain amount of change in the composition of our fauna during the past 40 years. Examples of such changes will be discussed in their proper place.

Since the publication of the report of Verrill and Smith no work has appeared upon American marine ecology of a magnitude at all comparable with it. Annotated lists of species have been published, which have amended and extended the records of that report; but these, for the most part, have been restricted to single divisions of the animal kingdom and have given the bare data of distribution, with but slight comment. Probably the most comprehensive of these recent annotated lists dealing with the marine fauna of any portion of the Atlantic coast of the American continent is Whiteaves's "Catalogue of the Marine Invertebrata of Eastern Canada." This work lists more than a thousand species of invertebrate animals, and is said to consist "of a systematic list of all the species from the eastern Canadian seaboard that have been so far identified or described, with notes on their geographical distribution and bathymetrical range."

In order to compare the fauna of these two sections of the American coast, belonging to two recognized zoogeographical "regions," we have indicated in our table the number of species belonging to each major group, which are common to the Woods Hole and the Canadian lists. These figures are probably, in some cases, too low, owing to our failure to recognize the same species under two different names.

Ever since the days of Edward Forbes the exploration of English waters by means of the dredge has been actively prosecuted, and the fauna of various sections of the coast has been catalogued. In recent years the two principal centers for English faunistic studies have been Plymouth and Liverpool. Commencing with the foundation of the Plymouth laboratory in 1887, the waters of that region have been diligently explored, and from time to time lists have been published comprising the entire known fauna and flora or particular groups of organisms.[a] The last of these inclusive lists was published in 1904 and embraced all previous records, so far as they were believed to be authentic.[b] Over 1,200 species of invertebrate animals are catalogued in this report, which includes copious notes upon local distribution, reproduction, and general ecology.

[a] These may be found in the Journal of the Marine Biological Association, from 1887 to the present time.
[b] Even this list has been supplemented to some extent.

In its scope this Plymouth census covers an area which "roughly speaking, ... may be said to lie within a radius of 15 miles from the laboratory," and "extends from the shore to a depth of 30 to 35 fathoms." The area is thus somewhat smaller than is comprised within the Woods Hole region,[a] as we have defined it, though considerably greater depths have been included. But the scope of the two catalogues is fairly comparable, save for the exclusion of vertebrates from the Plymouth list, and some instructive comparisons are possible. In the Plymouth region, as in our own, systematic dredging has been carried on throughout considerable areas. Indeed the biological survey conducted by E. J. Allen [b] and his colleagues in adjacent portions of the English Channel appears to be one of the most exhaustive investigations extant of the relations between fauna and bottom deposits.

Commencing with 1885, another group of English biologists, under the lead of Prof. W. A. Herdman, have been engaged in a systematic study of the fauna of the Irish Sea.[c] Especial attention has been devoted to Liverpool Bay and to the vicinity of the Isle of Man, but a large part of the bottom of the Irish Sea has been explored, and the fauna and bottom deposits have been analyzed with great thoroughness. The results of this work have been communicated from time to time in the Reports of the Liverpool Marine Biology Committee, in the Transactions of the Liverpool Marine Biological Society, in the Reports of the British Association, as well as in a separate series of volumes entitled "Fauna of Liverpool Bay" (no. I–V). A complete list of the species recorded up to that date was published in the report of the British Association for 1896, and a synopsis of this list has been included in our comparative table.

The greater number, at least, of the leading biological stations of the world have devoted more or less attention to the enumeration of the organisms found in their immediate vicinity. This is preeminently true of the Naples station, the pioneer among marine laboratories. One need allude only to the splendid monographs comprised in the "Fauna und Flora" series, and to the less pretentious faunistic contributions published from time to time in the "Mittheilungen" of the station. So far as we know, however, no single inclusive list of species has been published which renders possible, without great labor, a comparison with the fauna of Woods Hole.

At the Trieste station, maintained by the Austrian Government on the Adriatic Sea, a census of the local marine fauna has for many years past been conducted by Graeffe (1880–1903), and lists of species have appeared comprising most of the chief divisions of the animal kingdom. Here, as at Plymouth, abundant data are recorded respecting reproduction and general ecology. In the last column of our comparative table we have indicated the number of species recorded by Graeffe for each group of animals.

It is obvious that these various faunal catalogues differ widely from one another in respect to their scope. Three of them are restricted to the invertebrates, while in only one (that of Woods Hole) are the marine birds listed. Likewise, at Woods Hole alone, among these stations, has any serious attempt been made to list the fish parasites, either the worms or the copepods. On the other hand, the Foraminifera and some other groups have received relatively little attention in our survey.

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[a] In reality, however, the vast majority of our records relate to a region of much smaller extent.

[b] See Allen (1899), p. 365–542.

[c] Prof. Herdman had some years earlier taken part in a census of the invertebrate fauna of the Firth of Forth. (See Leslie and Herdman, 1881.)

Again, the areas comprised differ widely in their extent, ranging as they do from restricted bodies of water, such as the Gulf of Trieste, to such extensive tracts of ocean as the Irish Sea or the seas bordering the eastern coast of Canada. Even the report of Verrill and Smith, despite its title, covered a much wider territory than that dealt with in the present work, and included greater depths of sea. Indeed, with the exception of the waters of the Gulf of Trieste, those of the Woods Hole region, as here understood, are the most restricted among those considered in respect to bathymetric range.

It would not be fair, therefore, to look to the parallel columns of this table for any really accurate comparison of the faunas of the several regions referred to, either in respect to their wealth or their composition. Especial reservation must be made in accepting the figures representing the number of species common to Woods Hole and to Canada or Plymouth. It is likely that the number of common species has been underestimated, partly owing to the difficulty, without exhaustive research, of resolving the synonymy of the various species; partly to the probable identity, not yet recognized, of various European and American forms. If due caution be exercised, however, we believe that facts of real value may be brought out by the comparison.

Species are here listed as doubtful which are either undetermined or of doubtful identity, provided that they are believed to be distinct from any others included in the same list. Varieties are omitted, except in those cases where the species is represented only by one of its varieties.

SYNOPSIS OF WOODS HOLE MARINE FAUNA, AS COMPARED WITH THAT OF CERTAIN OTHER REGIONS FOR WHICH LISTS HAVE BEEN PREPARED.

Groups of organisms.	Woods Hole (present report).	Verrill and Smith.	Canada (Whiteaves).		Plymouth.		Irish Sea (Herdman).	Trieste (Graeffe).
			Number of species.	Common to Woods Hole.	Number of species.	Common to Woods Hole.		
Protozoa [a]	99(+5?)	...	64	13	109	19	239	...
Porifera	12(+7?)	8(+9?)	36(+2?)	6	18	4(+1?)	58	45
Hydrozoa	132(+8?)	60(+1?)	66	41	121	34(+6?)	129(+1?)	64(+2?)
Scyphozoa	5(+1?)	5(+2?)	5	2	8	(2?)	6	9
Actinozoa	14(+3?)	12	44	4	34	2(+1?)	24	29
Ctenophora	8	4(+1?)	4	4	3	2	4	5
Turbellaria	40(+1?)	9	4	2	62(+2?)	2 (+?)	27	...
Trematoda	52(+4?)	...	...	...	...	...	...	...
Cestoda	71(+3?)	...	...	...	...	...	...	...
Nemertinea	25(+1?)	13(+5?)	20(+1?)	7	35	5	24(+2?)	...
Nemathelminthes	33(+5?)	2	...	...	...	...	...	...
Chætognatha	1(+1?)	1(+1?)	...	...	1	...	1	2
Dinophilea	3	...	...	...	1	...	1	...
Bryozoa	76(+5?)	29(+4?)	115	45(+2?)	103(+1?)	28(+4?)	136	56
Brachiopoda	...	...	4	...	...	...	2	...
Phoronis	...	...	...	...	1	...	...	1
Asteroidea	6	5	29	5	9	1	12	10
Ophiuroidea	6	5	21	3	10	(1?)	7	8
Echinoidea	4	4	3	2	8	...	7	5
Holothuroidea	8(+1?)	6(+1?)	15	4	8	1	8	13
Crinoidea	...	...	3	...	1	...	1	1
Polychæta [b]	133(+10?)	88(+13?)	105(+1?)	29	148	10	87(+1?)	135

[a] Of 98 Woods Hole Protozoa, only 29 are Foraminifera, while all of those in the other columns belong to the latter group.
[b] Including Polygordiidæ.

SYNOPSIS OF WOODS HOLE MARINE FAUNA, AS COMPARED WITH THAT OF CERTAIN OTHER REGIONS FOR WHICH LISTS HAVE BEEN PREPARED—Continued.

Groups of organisms.	Woods Hole (present report).	Verrill and Smith.	Canada (Whiteaves).		Plymouth.		Irish Sea (Herdman).	Trieste (Graeffe).
			Number of species.	Common to Woods Hole.	Number of species.	Common to Woods Hole.		
Oligochæta	11	4	...	...	3	1	2	2
Myzostomida	...	...	...	...	1	...	(1?)	2
Hirudinea	4	5(+1?)	...	...	1	...	1	3
Gephyrea [a]	3	2(+1?)	5(+1?)	1	3	1	1(+1?)	5
Phyllopoda	2(+1?)	1	...	...	3	2	2	4
Ostracoda	26	...	29(+9?)	10	6	...	57(+1?)	9
Copepoda (free)	25(+1?)	1(?)	1(+1?)	...	24	5	195	56
Copepoda (parasitic)	58(+2?)	19(+5?)	2(+1?)	...	1	...		109(+1?)
Cirripedia	15(+2?)	13	10	6	10	4	10	15
Phyllocarida	...	...	1	...	1	...	1	1
Amphipoda	71(+6?)	31(+12?)	70(+4?)	20	52	7(+1?)	129	49(+1?)
Isopoda [b]	25(+3?)	21	26	12	30	5	24	51
Cumacea	8(+2?)	5	11	4(+1?)	6	1	17	9
Stomatopoda	3	1	...	...	1	...	...	2
Schizopoda	5	3(+1?)	7	3	24	1	16	11
Decapoda	51(+4?)	36	34	12	71	3	61	73
Xiphosura	1	1	...	...	...	...	...	...
Pycnogonida	5(+1?)	1(+1?)	11	1(+1?)	8	2(+1?)	12	...
Arachnida	1	2	...	...	...	...	...	...
Insecta	16(+13?)	20(+5?)	...	...	...	...	...	...
Pelecypoda	70(+6?)	84	100	55	86	5	108(+3?)	107
Amphineura	2	2	8	1	6	...	10	5
Gastropoda [c]	129(+10?)	97(+1?)	160	63	164	15	207(+3?)	285
Scaphopoda	...	...	5	...	1	...	3	2
Cephalopoda	4	5	13	...	11	...	7	9
Enteropneusta	1	1	...	...	...	...	...	1
Tunicata	22(+10?)	20(+5?)	27(+1?)	10	36	2	45(+14?)	75
Cephalochorda	...	...	...	...	...	...	1	...
Pisces	247(+6?)	...	...	...	...	...	134	181
Reptilia	5	...	...	...	...	...	...	...
Aves	75	...	...	...	...	...	...	...
Mammalia	12(+3?)	...	...	...	...	...	12	...
Total	1,625(+125?)	626(+69?)	1,058(+21?)	365(+4?)	1,229(+3?)	162(+17?)	1,828(+27?)	1,449(+4?)
Invertebrates (including tunicates)	1,286(+116?)	626(+69?)	1,058(+21?)	...	1,229(+3?)	...	1,681(+27?)	1,268(+4?)
Vertebrates	339(+9?)	...	...	...	...	...	147	181

[a] Comprising both the "Gephyrea armata" and the Sipunculoidea.
[b] Some of the species comprised in the Trieste list are not marine.
[c] Seventy of the Plymouth gastropods are nudibranchs.

Before leaving this hasty comparison between our own biological census and a few of the similar undertakings elsewhere, reference should be made to certain works in which some features of our own survey are closely paralleled. We must mention first of all the explorations in the Kattegat of the Danish steamer *Hauchs*, under the charge of C. G. J. Petersen. The resemblance between the Danish project and our own lies in the successful endeavor to correlate the distribution of various species with peculiarities of bottom and of water temperature, and particularly in the presentation of a number

of charts portraying the actual distribution patterns of certain species. Unfortunately Petersen thought fit to plot upon each of these charts the records for a considerable number of species (26 in one case), thus rendering it very difficult to distinguish the distribution of any one of these, and to a large extent impairing the usefulness of the charts. Petersen's "General results" (of which an English translation is provided) includes one of the most philosophical discussions which have appeared of the factors determining the distribution of marine animals.

The important paper of E. J. Allen (1899) has already been mentioned in an earlier chapter. Allen has, among other things, presented 16 charts, each portraying the distribution of several species, usually members of the same zoological class. Each species is indicated by a letter, its relative abundance at various points being denoted by the style of type. These distributions are plotted upon an identical form, having the bottom characters indicated by conventional shading. Only scattered patches are thus represented, however, and in general the charts have little in common with our own.

The detailed distribution of numerous marine species has likewise been ascertained by Herdman and his associates for the neighborhood of the Port Erin biological station on the Isle of Man. Seven distribution charts have been published (Herdman, 1901), each chart embracing one or more entire groups of organisms. Upon these charts each species is designated by a number, so that the total distribution of any given form may be ascertained (though rather laboriously) by finding all the various positions occupied by the number which has been assigned to it.

Chapter IV.—THE FAUNA CONSIDERED BY SYSTEMATIC GROUPS.

1. PROTOZOA.

This phylum is represented in our list by 99 determined species, together with 5 others which are entered as undetermined or doubtful. Of the 99 determined species 32 are assigned to the Rhizopoda, 2 to the Heliozoa, 21 to the Mastigophora, 38 to the Ciliata, 5 to the Suctoria, and 2 to the Sporozoa. All but 2 of the rhizopods belong to the subclass Foraminifera, of which 23 species have been encountered during our dredging, and a number of others collected on piles, etc. With the exception of two or three species, no Foraminifera had been recorded for local waters prior to the operations of the present survey.

The data which we have utilized relative to the Protozoa are derived mainly from two sources. The Foraminifera were obtained during the dredging operations of 1905 and 1907, and were, without exception, identified by Dr. J. A. Cushman, of the museum of the Boston Society of Natural History. A nearly complete list of these species has already been published by Dr. Cushman (1908). The records for the other divisions were taken from the report of Calkins (1902) upon the marine Protozoa of the region, to which have been added a very few data from the writings of Peck (1894 and 1896). In our annotated list the classification which we have adopted is that of Professor Calkins, except in the case of the Foraminifera. For the treatment of the latter group Dr. Cushman is responsible.

The local records for Protozoa are comparatively scanty. The report of Calkins represents the search of one investigator for a period of two months during the midsummer alone. With very few exceptions, the forms listed were taken from the local pier, close to the laboratory building. Nevertheless, as a result of this somewhat superficial examination, Calkins was able to record 72 species, 8 of which were described as new to science.[a]

No search was made for Foraminifera during the summers of 1903 and 1904, though *Discorbina rosacea* was noted on several occasions without its identity being recognized. Dr. Cushman's presence at the Woods Hole laboratory during the season of 1905 directed our attention to these organisms, and bottom samples from most of the stations of that year were examined by him personally. The dredging during that season was restricted to Vineyard Sound (*Fish Hawk*) and the eastern shore of Buzzards Bay (*Phalarope*). Two years later, in order to obtain more complete records for the Foraminifera and certain other organisms, about 25 of the *Fish Hawk* stations in Vineyard Sound and about 30 of those in Buzzards Bay were revisited. Bottom samples from all these points were submitted to Dr. Cushman, who was thus enabled to provide us with important supplementary data. Only two species were found, however, which had not previously been recorded by us, and it is Dr. Cushman's belief that the list of local Foraminifera is tolerably complete. But our knowledge of their distribution within the region was greatly extended by these later dredgings. We have accordingly departed from the custom, which has been followed for most other groups, of including in our distribution charts

[a] Two of these are no longer regarded by Dr. Calkins as good species.

only data derived from the regular dredging operations of the first three years, and have plotted out the records of these supplementary dredgings in the case of the Foraminifera.

The meager representation of the Foraminifera in our local fauna is realized in a striking way when the present records are compared with those for deep-sea dredging. There occurs in these waters none of the "ooze" which forms such a marked feature of the ocean bottom the world over. The maximum number of species found by the survey at any single station was 9 (*Phalarope* station 78), and the average number found throughout the period during which a careful examination was made [a] was 1.4 species per dredge haul. During the *Challenger* dredgings, it was not uncommon to find 100 species of Foraminifera at a single station, and over 240 species were found in one case.

The Canadian list of Whiteaves comprises 64 members of this group, 13 of which are known to occur in our local waters; while the Plymouth list comprises 109 species, 19 of which are common to Woods Hole. The list for the Irish Sea comprises 209 species of Foraminifera. All three of these foreign surveys have extended to waters of considerably greater depth than any which occur within the "Woods Hole region" of the present report. The great disparity in the wealth of Foraminifera is thus largely accounted for.

Distribution charts have been plotted for those 9 of our local species which were taken at 10 or more of the dredging stations. Regarding the distributions here portrayed few definite conclusions can be offered, owing to the incompleteness of the records upon which they are based. As already stated, these organisms were not looked for during the regular dredgings of the *Fish Hawk* in Buzzards Bay, nor during the *Phalarope* dredging in Vineyard Sound, though the former deficiency was in some measure rectified during the summer of 1907. As a consequence, one might easily be misled respecting the relative abundance of certain species on various parts of the local sea floor. For example, most of the species seem to be scarce or absent in the central parts of Buzzards Bay. This is doubtless due in part to the fact that material was examined from less than 30 stations in the deeper parts of the Bay, as compared with about 125 in the Sound. During the supplementary dredging of 1907 a number of species (*Miliolina seminulum, Polymorphina lactea, Polystomella striatopunctata,* and *Rotalia beccarii*) were encountered at *Fish Hawk* stations in the Bay; the two last named, indeed, being taken with considerable frequency. It does not seem unlikely, however, that the soft, black mud which prevails throughout much of Buzzards Bay is unfavorable to some species of Foraminifera, as to many other organisms of all sorts. On the other hand, with a very few exceptions, every species which was recorded from Vineyard Sound was taken with greater or less frequency along the island shores of Buzzards Bay.

One feature in the distribution of nearly all the species which have been plotted is the greater frequency with which they occur at the western end of Vineyard Sound. Indeed, certain species are entirely lacking in the eastern half. So far as is known, the same degree of care was taken in preserving and examining the bottom samples throughout the whole length of the Sound during the *Fish Hawk* dredging of 1905. This greater abundance of Foraminifera at its western end would thus seem to be a genuine fact in distribution. Whether it is due to the character of the bottom, which is predominantly sandy in the western half of the Sound, or to the comparative absence of the swift tidal currents in the latter part can not be stated with any certainty.

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[a] Including only the *Fish Hawk* and *Phalarope* stations of 1905.

The following is a list of the Foraminifera dredged by the Survey. The asterisk denotes species which were recorded from 10 or more stations:

Astrorhiza limicola.
Reophax dentaliniformis.
Haplophragmium canariense.
Webbina hemispherica.
Spiroculina limbata.
*Biloculina ringens (chart 1).
Biloculina tubulosa.
*Miliolina seminulum (chart 2).
*Miliolina oblonga (chart 3).
*Miliolina circularis (chart 4).
Miliolina boueana.
Miliolina venusta.
Miliolina bicornis.
Verneuilina polystropha.
*Polymorphina lactea (chart 5).
Polymorphina concava.
Polymorphina rotundata.
*Discorbina rosacea (chart 6).
Truncatulina lobatula.
*Pulvinulina lateralis (chart 7).
*Rotalia beccarii (chart 8).
*Polystomella striatopunctata (chart 9).
Polystomella crispa.

2. PORIFERA.

The treatment of the sponges constitutes decidedly the weakest spot in our report. In addition to the naturally great difficulties presented to the systematist by these animals is the fact that the group has been very largely neglected by local zoologists. Since the work of Verrill in the early seventies, in which a considerable proportion of the forms recorded were not specifically determined, no attempt has been made to list or describe the sponges of the shallower waters of the New England coast. Verrill's later studies were devoted to species taken at considerable depths and belonging to a fauna quite distinct from that under consideration. Lambe,[a] it is true, has given much attention to the Canadian sponges, some of which are identical with species included in the present work, and H. V. Wilson[b] has reported upon the Porto Rico forms, none of which, however, are known to occur in the Woods Hole region. The paucity of our data relating to the shallow-water species constitutes a conspicuous gap in our knowledge of the local fauna.

In view of this condition of affairs, Dr. J. A. Cushman, of the museum of the Boston Society of Natural History, undertook during the summer of 1905 and during the following winter to identify the sponges collected in the course of the Survey dredging. Twelve species were specifically determined by him with more or less certainty, four of these being forms which had been overlooked or left unidentified by Verrill at the time of the writing of the "Report upon the Invertebrate Animals of Vineyard Sound." Certain other species were provisionally assigned to genera, and an even greater number remained undetermined. It was unfortunately impossible for Dr. Cushman to continue this work after 1905, and thus the results here presented are fragmentary and perhaps not wholly consistent.

In all, 14 determined species of sponges are comprised in our annotated list, the identity of which is not certain in all cases. We have also included, on the authority of Verrill and of Cushman, a number of unidentified forms, to which generic names have been provisionally assigned.

The Canadian list of Whiteaves comprises 36(+2?) species of Porifera (identified in the main by Lambe), six of which are common to our Woods Hole list. At Plymouth only 18 sponges have been catalogued, of which four or five are common to our own

[a] Sponges from the Atlantic coast of Canada. Transactions of the Royal Society of Canada, vol. II, sec. IV, 1896, p. 181–211.
[b] Bulletin of the U. S. Fish Commission, vol. XX, 1900 (1902), p. 375–411.

waters.[a] Herdman records 58 species from the Irish Sea, while Graeffe lists 45 species from the Gulf of Trieste. As implied in the foregoing discussion, it is likely that the Woods Hole list will be greatly extended by further investigations.

Referring to our dredging records for this group, the distributions of certain forms, such as *Cliona celata*, *Microciona prolifera*, *Tethya gravida*, and *Polymastia robusta*, have probably been ascertained with a fair degree of accuracy. On the other hand, it is probable that some confusion occurs between the two species of *Chalina*, since specimens which were listed in the field records as *C. arbuscula* were in a number of cases subsequently identified as *C. oculata* (see catalogue). For this reason a single chart has been prepared, which includes all the records for this genus. A similar confusion exists regarding the two species of *Halichondria* (*H. panicea* and *H. caduca*). And in addition to these equivocal records specimens belonging to entirely undetermined species of this genus are listed from about 20 of the regular dredging stations and were doubtless taken at many others.

Under such circumstances little of a general nature can be said regarding the distribution of these animals in local waters. The species having the most general occurrence was *Cliona celata* Grant (=*Spongia sulphurea* Desor), which was recorded from 171 of the regular stations. This form seems to flourish nearly as well on one kind of bottom as another, though it is much less common in the western half of the Sound than in the eastern half.[b] That its scarcity in the former region is not due to the lower summer temperature of the water there is rendered probable by the fact that this species has been reported by Lambe from Prince Edward Island, in the Gulf of St. Lawrence. It has not been taken by us, however, at Crab Ledge, where many of the typical cold-water species occur and many southern ones are lacking.

Microciona prolifera is not uncommon in the Sound in the form of reddish incrustations on the surface of stones and shells. In Buzzards Bay, particularly in the inshore waters, it frequently grows up into the characteristic and beautiful arborescent form.

A species of *Grantia*, which has been regarded as *G. ciliata* (Fabricius) by Verrill and others, is common on piles, and one or more species of the same genus (not improbably identical with the foregoing) were encountered at various points in dredging (chart 10).

An interesting case of restricted distribution is exemplified in the case of *Polymastia robusta*, for which, however, no chart has been prepared, owing to the limited number of stations from which it was recorded. This readily recognizable species was taken by us a few times at the western entrance of Vineyard Sound and in the mouth of Buzzards Bay; likewise at five of the seven regular stations of the survey at Crab Ledge. It is thus a representative of that colder water fauna which just enters the limits of our region. So far as we know, this species has not been listed from points farther south upon our coast than Marthas Vineyard, though ranging northward at least to the Gulf of St. Lawrence.

Another case of definitely restricted distribution, for which, however, no explanation can be offered at present, is that of *Tethya gravida*. This species, which was first described by Hyatt from specimens taken in Buzzards Bay, was encountered by us eight times,

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[a] It is stated by the authors that "the list is a very imperfect one, many common species not having been identified and recorded."

[b] The chart for this species likewise shows a considerable gap in the central region of the Bay, but specimens were later taken at several points in this area.

but always within a very limited area near the head of the Bay. Mr. G. M. Gray also reports finding it at Bird Island, in the same vicinity. We know of no other records of the occurrence of this species.

The following is a list of the species recorded from the Survey dredgings. The asterisk denotes those which were taken at 10 or more of the stations (exclusive of Crab Ledge).

Ascortis fragilis.
?*Grantia ciliata (chart 10).
*Cliona celata (chart 11).
Polymastia robusta.
Tethya gravida.
Halichondria panicea.
Halichondria caduca.
Chalina arbuscula.
Chalina oculata.
Esperella modesta.
Desmacidon palmata.
Myxilla sp. undet.
*Microciona prolifera (chart 13).

A chart (12) has been prepared based upon the equivocal records for one or both species of *Chalina*.

Of the three determined species so common as to have been recorded from 10 or more stations, one appears to be distinctly northern, another to be distinctly southern, while the third appears to have a range of nearly equal extent in both directions. The ranges, as given by Verrill (1873), are as follows:

Grantia ciliata: Rhode Island to Greenland.
Cliona celata: South Carolina to Portland, Me.
Microciona prolifera: South Carolina to Cape Cod.

Cliona, as already stated, has since been reported from the Gulf of St. Lawrence.

3. CŒLENTERATA.

Our list comprises 160 determined species belonging to this phylum, together with 12 others which are undetermined or doubtful. These are assignable to 54(+3?) families and 98(+7?) genera. The representation of the various classes is as follows: Hydrozoa, 132(+8?); Scyphozoa, 5(+1?); Actinozoa, 14(+3?); Ctenophora, 8. Among these, 28(+1?) of the Hydrozoa and 4(+2?) of the Actinozoa have been encountered during the Survey dredgings. The Scyphozoa and Ctenophora, owing to their pelagic mode of existence, do not figure in the dredging records, although the latter frequently and the former occasionally were taken during the reeling in of the dredge or trawl. Furthermore, a large majority, even of the fixed hydroids, comprised in our catalogue, find their proper habitat in shallower waters, where they grow attached to plants or woodwork, and are rare or absent upon the bottoms reached by the dredge.

The identification of specimens concerning which any doubt was felt by the collectors was made by Prof. C. W. Hargitt, of Syracuse University, and Prof. C. C. Nutting, of the University of Iowa, to whom we again take occasion to express our thanks for their assistance. The identification of the 1903 specimens was performed by Prof. Nutting, that of the subsequent material by Prof. Hargitt. A comparison of the determinations made by these two authorities revealed certain differences of opinion, some of which were later adjusted. In other cases, such differences are indicated in the text. Prof. Hargitt was present at the laboratory as a member of the investigation staff during the summers of 1905 to 1909, inclusive, and the records for those seasons are doubtless on this account more complete than during the two previous seasons of the Survey's

work. During these two earlier seasons it seems probable that certain minute and inconspicuous forms were overlooked by the collectors. It is likewise probable that some closely related species were confused in the field records. This is perhaps true to some extent even of such common forms as *Eudendrium ramosum* and *E. dispar*, though samples from many of the stations were fortunately preserved for future reference.

The apparent scarcity of nearly all hydroids throughout Buzzards Bay, as portrayed by the distribution charts, may be due in some measure to the fact that no specialist in this group was present during the season of 1904, when the original *Fish Hawk* dredging was carried on in that body of water. We are, however, inclined to attribute a minor importance to this fact in judging of the occurrence of hydroids in Buzzards Bay, since records from 29 stations which were redredged in 1909 do not materially affect our ideas regarding the local distribution of these organisms.

The data utilized in the preparation of our catalogue, aside from those derived from our own collecting operations, are based principally upon the published works of A. Agassiz (1865), Verrill (1873), Nutting (1901), and Hargitt (1901–1908). In addition, special records were furnished by members of the investigation staff or by others. Particular mention must be made of some rather extensive manuscript notes kindly contributed by Prof. Hargitt. The latter authority likewise consented to revise our annotated list in respect to nomenclature and classification, though he regards these as being still to a considerable extent provisional.

About 20 species new to science have been described during the past 10 years by Hargitt, Nutting, Mayer, and others from specimens taken within the limits of the present region. At least two of these (*Ectopleura prolifica* Hargitt and *Keratosa complexum* Hargitt) were described from specimens obtained during the course of the survey dredging; while a number of them were first collected and described during this same period, though independently of the dredging operations. Still other species (*Calyptospadix cerulea, Opercularella pumila, Sertularia versluysi, Sertularella polyzonias, Aglaophenia minuta, Tealia crassicornis*), though more or less familiar elsewhere, have been added to the known fauna of these waters through the dredging and collecting operations which form the chief subject of the present volume.

Verrill and Smith (1873) recorded 72 determined species of coelenterates from definitely stated points within the limits of the region, together with a considerable number of others which were doubtful, undetermined, or extralimital. Among the foregoing 72 species were 57 Hydrozoa, 3 Scyphozoa, 8 Actinozoa, and 4 Ctenophora. Certain of the species listed by Verrill (e. g., *Halecium gracile, Edwardsia farinacea*, and *E. lineata*) do not appear to have been encountered in local waters by later naturalists. Indeed, repeated search by our parties for *Edwardsia lineata* at points where it was said to be abundant by Verrill failed to bring to light a single specimen. On the other hand, certain species which were not listed at all in the "Invertebrate Animals of Vineyard Sound" are now known to be common in these waters. Such are *Podocoryne carnea, Lizzia grata, Tubularia couthouyi, Staurostoma laciniata, Epenthesis folleata, Halecium halecinum, Gonionemus murbachii*, and *Sagartia luciæ*. The last-named species we know to be a recent immigrant into these waters, which probably arrived here within the past 15 years. Indeed it has, during this brief period, become by far the most abundant of our local actinians. Whether or not any of the other species are

immigrants of recent standing can not be stated. We have no satisfactory evidence that such is the case.

The Canadian list prepared by Whiteaves includes 66 Hydrozoa, 5 Scyphozoa, 44 Actinozoa, and 4 Ctenophora. Of these, 41 Hydrozoa, 2 Scyphozoa, 4 Actinozoa, and 4 (all) of the Ctenophora are common to our Woods Hole list. It is interesting that while the number of hydroids in the Canadian list is only half as great as in our own, the number of actinians is about three times as great.

The catalogue for Plymouth includes 121 Hydrozoa, 8 Scyphozoa, 34 Actinozoa, and 3 Ctenophora. Of these, 34 (+6?) Hydrozoa, 2 (?) Scyphozoa, (2+1?) Actinozoa, and 2 Ctenophora are known to be common to the Woods Hole region.

The list of Herdman for the Irish Sea comprises 129(+1?) Hydrozoa, 6 Scyphozoa, 24 Actinozoa, and 4 Ctenophora. There is a rather close agreement between the Woods Hole, Plymouth, and Irish Sea lists in respect to the number of Hydrozoa comprised. On the other hand, both of the latter lists agree in including a considerably greater number of actinians than have been recorded from the Woods Hole region.

For the Gulf of Trieste, Graeffe catalogues 64(+2?) Hydrozoa, 9 Scyphozoa, 29 Actinozoa, and 5 Ctenophora.

In all these comparisons the differences in area and in bathymetric range among the various regions must of course be kept in mind (see p. 87).

On the average 1.8 species of cœlenterates were recorded for each of the 458 regular stations of the Survey. The species found to be of most general occurrence was the coral *Astrangia danæ*, which was encountered at 158 of the stations, this being the only cœlenterate which was so prevalent as to be recorded from one-fourth of the stations dredged. It is likely, however, that *Hydractinia echinata* was actually present in at least one-fourth of the dredge hauls, and that it was frequently overlooked by us in listing the species in the field.

Referring to the table on page 78, it will be seen that on the average nearly three times as many species of hydroids per dredge haul were recorded for the *Fish Hawk* stations in Vineyard Sound as for those in Buzzards Bay, while the average number of Actinozoa was the same in both bodies of water. The *Phalarope* stations in Vineyard Sound likewise show an excess of hydroids as compared with the stations in the Bay. From the table on page 79 it is evident that there is a greater wealth both of hydroids and of actinians on bottoms of gravel and stones than upon bottoms of mud or of pure sand. As respects Hydrozoa, the average number of species is nearly twice as great upon sandy bottoms as upon muddy ones. The distribution of most cœlenterates upon the local sea floor is, we believe, almost wholly conditioned by the character of the bottom.

Charts have been prepared showing the distribution, in local waters, of 10 species of Hydrozoa and 3 of Actinozoa. A list of these, with a statement of the geographical distribution of each is given below. Owing to the probable incompleteness of our earlier records for the Hydrozoa, the practice of basing our charts upon the original dredgings of the "regular" series only has not been adhered to for this group. The results of various supplementary dredgings (see p. 62) have been incorporated here as in the case of the Foraminifera and the Bryozoa.

These charts nearly all agree in showing the paucity of cœlenterate life in Buzzards Bay, to which reference has already been made. In fact, but two species (*Eudendrium ramosum* and *Astrangia danæ*) appear to be of anything like as general occurrence in the Bay as in the Sound. Two species among those charted were not recorded from a single station in the former body of water, while some of the others are confined within its limits to the extreme lower end or to the immediate neighborhood of land. This last condition is found to obtain in the case of many species belonging to nearly every group which do not thrive upon muddy bottoms, and their distribution is readily explainable by reference to this fact. Hydroids, as is well known, depend for support upon a solid substratum, such as is afforded by stones or dead shells, and their frequent occurrence upon bottoms which are listed as of pure sand is doubtless made possible by the presence of shells. Where such solid objects occur in the Bay, however, they are commonly more or less covered by soft mud. Nevertheless, at least one species of hydroid, *Eudendrium ramosum*, has established itself in considerable abundance on the floor of Buzzards Bay, a fact which is difficult to explain when we consider the almost total absence there of *Pennaria tiarella*, a species having a quite similar mode of life, and one which is abundant throughout the Sound.

Of considerable interest is the scarcity of *Hydractinia echinata* over the whole central area of Buzzards Bay. That this is not due to the scarcity within this area of the hermit crabs upon whose shells *Hydractinia* commonly dwells may be seen by reference to charts 109, 111 and 112, from which it is evident that the three commonest local Paguri are present throughout the entire Bay. It was at first thought possible that the non-appearance of this hydroid in the records of the *Fish Hawk* for Buzzards Bay might have been due to the failure of those responsible for the latter series of stations to include it when listing the contents of the dredge. That this is not a satisfactory explanation was shown in the course of some supplementary dredgings made during the summer of 1909. Hermit crabs (*P. longicarpus* and *P. annulipes*) were taken at 16 of the former *Fish Hawk* stations, but in only a single instance was *Hydractinia* met with, though *Podocoryne* was noted three times.[a]

Several of the hydroids, particularly *Tubularia couthouyi* and *Thuiaria argentea*, appear to show a marked preference for the eastern half of Vineyard Sound, where the bottom is in large measure stony. The distribution of *Obelia geniculata* is probably dependent upon that of certain algæ, to which it is generally found attached. Its abundance in the vicinity of Gay Head probably stands in direct relation to the occurrence there of large numbers of the kelps (*Laminaria*), upon which it frequently grows.

At least two very instructive cases are to be noted among the species charted, which appear to be intelligible only by reference to temperature conditions. We refer to the two actinians, *Alcyonium carneum* and *Astrangia danæ*. The former was found to be confined to the western end of Vineyard Sound and the extreme lower end of Buzzards Bay. It was not surprising, therefore, to meet with this species at several of the Crab Ledge stations. The case is quite comparable with that of the sponge, *Polymastia robusta*, referred to on page 94, and with many others which will be considered later. The limits of distribution for this species, so far as known, are: Rhode Island

[a] These supplementary dredgings, however, added several species to the fauna of the Bay, so far as recorded by us. These were *Clytia cylindrica*, *Pennaria tiarella* (which is doubtless common enough in shallow waters near shore), *Podocoryne carnea;* and *Schizotricha tenella*. While none of these were taken with sufficient frequency to affect seriously our conception of the cœlenterate fauna of the Bay, they point to the probability of considerable gaps in our original records for this group.

(Verrill) to the Gulf of St. Lawrence (Whiteaves). It is thus predominantly a northern form, which here approaches the southern limit of its range. Temperature is, with little doubt, the determining factor in the distribution of this species in local waters.

What appears to be a type of distribution exactly converse to the last is to be found in the case of the simple coral, *Astrangia danæ*. This species is abundant and of very general distribution throughout most of Buzzards Bay and Vineyard Sound. Indeed, it seems to be almost equally at home upon every sort of bottom, including soft black mud. Now, it will be seen that this form is conspicuously scarce at the open end of Vineyard Sound, i. e., in those same colder waters to which *Alcyonium* seems adapted to live. *Astrangia*, we learn, is a southern species, finding its northward limit at or near Cape Cod, so that its scarcity in the colder waters of the region[a] is thus perhaps explained. It may be suggested, on the other hand, that this gap in the local distribution of *Astrangia* may result from the character of the bottom, which is almost wholly sandy throughout the area in question. The species has, however, been dredged elsewhere upon bottoms of practically pure sand, so that this explanation does not seem sufficient.

If we seek for comparisons between the distributions of different members of the same genus, we find that our dredging records furnish few data of importance upon this subject. *Tubularia couthouyi* and *T. crocea* are seen to present certain characteristic differences, in that the former is largely restricted to stony bottoms, while the latter is of much more general occurrence upon the local sea floor and is abundant, likewise, even upon piles, etc., in shallow water. The former species has not been taken with living hydranths during the summer months, except at Crab Ledge and in the deeper waters south of Marthas Vineyard, while *T. crocea* has been found within the region in an active condition throughout the summer.

Referring to the two commoner species of *Eudendrium* (*E. ramosum* and *E. dispar*), it would seem probable that the distribution of the latter in local waters is far more restricted than that of the former. Indeed, our records point to the scarcity or absence of this species in Buzzards Bay,[b] a condition which affords an interesting contrast to that of *E. ramosum*, one of the few hydroids which were dredged with any frequency in the latter body of water.

Even more striking differences of habitat shown by closely related species of cœlenterates might be chosen among genera which do not figure in our dredging records at all, e. g., *Edwardsia* and *Sagartia*.

The following is a list of the species taken in the course of the Survey dredging. As usual, those species are designated by an asterisk which were taken at 10 or more of the stations:

HYDROZOA.

Ectopleura prolifica.
*Pennaria tiarella (chart 14).
Podocoryne carnea.
*Hydractinia echinata (chart 15).
*Eudendrium ramosum (chart 16).
*Eudendrium dispar (chart 17).
Eudendrium carneum.
Eudendrium capillare.
Eudendrium album.
*Tubularia couthouyi (chart 18).
?Tubularia spectabilis.
Tubularia tenella.

[a] It was not found by us at Crab Ledge.

[b] In the course of the 29 supplementary dredge hauls in Buzzards Bay in 1909, *E. ramosum* was taken eight times, but *E. dispar* was not noted once.

Tubularia crocea (chart 19).
Clytia cylindrica.
Campanularia verticillata.
Obelia commisuralis.
*Obelia geniculata (chart 20).
Hebella sp. undet.
Keratosum complexum.
Lovenella grandis.
Opercularella pumila.
Calycella syringa.
*Halecium halecinum (chart 21).
Sertularia pumila.
*Thuiaria argentea (chart 22).
Thuiaria cupressina.
Sertularella gayi.
Sertularella tricuspidata.
Hydrallmania falcata.
*Schizotricha tenella (chart 23).

ACTINOZOA.

*Alcyonium carneum (chart 24).
?Pterogorgia gracilis (one small dead fragment).
*Metridium dianthus (chart 25).
Tealia crassicornis.
*Astrangia danæ (chart 26).

If we consider, with respect to their known ranges upon our coast, these 13 species of cœlenterates which were of most frequent occurrence in our dredge hauls, we may group them as follows:

Predominantly northern.

Hydractinia echinata	Greenland (Mörch) to Charleston, S. C. (McCready).
Eudendrium dispar	Bay of Fundy to Vineyard Sound (Verrill).
Halecium halecinum	Gulf of St. Lawrence (Whiteaves) to Long Island Sound (Hargitt).
Thuiaria argentea	North Polar regions to Maryland (Nutting).
Alcyonium carneum	Gulf of St. Lawrence (Whiteaves) to Rhode Island (Verrill).
Metridium dianthus	Labrador to New Jersey (Verrill).

Predominantly southern.

Pennaria tiarella	Maine to West Indies (Mayer).
Schizotricha tenella	Marthas Vineyard (Nutting) to Beaufort, N. C. (Fraser).
Astrangia danæ	Cape Cod to Florida (Verrill).

Having range of approximately equal extent north and south.

Eudendrium ramosum	Labrador (Verrill) to Bermuda and Beaufort, N. C. (Hargitt).
Obelia geniculata	On our coast recorded from Labrador (Verrill) to Beaufort, N. C. (Fraser). [Cosmopolitan, according to Mayer.]

Range of doubtful extent.

Tubularia couthouyi	Probably predominantly northern.
Tubularia crocea	Casco Bay (Hargitt) to Brooklyn, N. Y. (Verrill), and perhaps to Charleston, S. C.

Thus six of these species appear to be predominantly northern in their range, while only three are known to have a range which is predominantly southern. This is a condition different from that shown by the local representatives of most of the phyla of animals, which as a rule show a decidedly southern bias. We do not believe, however, that this difference has any special significance, particularly since the proportion of our cœlenterates which are common to Canadian waters is no greater than that for the fauna at large.

With the exception of the two cases discussed above (*Alcyonium* and *Astrangia*), none of these species appears to be distributed in relation to temperature in local waters.

In the foregoing calculation we are of course only considering a few of the commonest bottom-dwelling species. Were we to include the multitude of pelagic forms (Medusæ), many of which are stragglers borne hither by the Gulf Stream, it is probable that the ratio of northern to southern forms would be quite different.

4. PLATYHELMINTHES, NEMATHELMINTHES, ETC.

The various classes of "flat worms" are represented in our check list as follows: Turbellaria, 40(+1?); Trematoda, 52(+4?); Cestoda, 71(+3?); Nemertinea, 25 (1?). Of the "round worms" there are 14 Acanthocephala and 21(+5?) Nematodes. The anomalous group of Chætognatha is represented by a single determined species of *Sagitta*, though there may be one or more undetermined members of the genus in local waters. The Dinophilea, which are included in the present section only for the sake of convenience, appear to be represented by at least three species, none of which, however, has been observed during the Survey dredgings.

Except for a comparatively small number of nemerteans (6 species), no representatives of these groups of "worms" appear in the dredging records. Certain nemerteans are abundant locally in the shallow waters near shore, where they live under stones or burrow in the mud or sand; while Turbellaria of a considerable number of species are likewise common in shallow weedy waters. From the fragmentary condition of all the nemerteans which were dredged by us it is evident that the apparatus employed was ill-adapted to unearthing deeply burrowing worms such as these. It is likely, therefore, that our scanty records give a very imperfect idea of the distribution of these species throughout the area dredged.

It was accordingly inevitable that the greater part of our data respecting these groups of organisms should be derived from previously published statements. The records for the Turbellaria and Nemertinea are based chiefly upon the works of Verrill and of Coe, supplemented, in the case of the latter group, by our own dredging records and by a set of manuscript notes kindly furnished by Prof. Coe.[a] The records for the endoparasitic worms (trematodes, cestodes, nematodes, and Acanthocephala) are based for the most part upon the works of Prof. Edwin Linton, who for many years has studied our local fish parasites on behalf of the Bureau of Fisheries. To these published sources of information we must add, however, some valuable unpublished notes, kindly put at our disposal by Dr. Linton.

Acknowledgments for the revision of those portions of the checklist which include these groups are due Prof. Linton and Prof. Coe. To Dr. Coe we are likewise indebted for the identification of the nemerteans taken during the Survey dredging. We have thought it expedient to follow Dr. Linton in retaining provisionally in their earlier sense certain of the genera (e. g., *Distomum*), which have been greatly subdivided by some recent writers. In his own published works, Dr. Linton has taken occasion fully to acknowledge the invaluable assistance of Mr. Vinal N. Edwards, who collected a large part of the material described by him.

Of the 41 Turbellaria comprised in our catalogue, 9 were listed by Verrill in the report of 1873, though only 2 of these were recorded specifically for points within the limits of our region. The records for most of the other species have been derived from Prof. Verrill's later writings and from the recent report of von Graff.

The number of Turbellaria which have been listed from Plymouth, England, is about fifty per cent greater than that contained in our catalogue, and so far as is apparent only two of the species are common to the two regions. Herdman's list for the Irish Sea contains 27 members of this group.

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[a] The additional records for Turbellaria contained in the important paper of von Graff (1911) have also been incorporated during the revision of the present report.

Of the 26 nemerteans of our catalogue, 7 appear to be common to the Canadian list and 5 to that of the Plymouth station. The former list comprises 20(+1?) species, the latter 35. Herdman has listed 24(+2?) species for the Irish Sea. None of the groups of parasitic worms appear to have been catalogued at any of these other stations.

Under the circumstances which we have stated, it is natural that few generalized statements can be made regarding the distribution of these groups locally. The parasites were of course taken from the fishes, and it would therefore be futile in most cases to state specific localities for these. Only such species have been listed, however, as are believed to have been taken from fishes captured in strictly local waters.

Regarding the nemerteans, it may be said that in 18 out of the 21 occasions upon which these worms appear in the dredging lists they were taken in Buzzards Bay. It is quite possible, however, that these forms are much more abundant throughout Vineyard Sound than would be implied by these records. As is well known, many of the species burrow rather deeply into the shores and bottoms which they frequent, and considerable digging is often necessary in order to unearth them. Now, the soft bottoms of Buzzards Bay were doubtless, as a rule, penetrated more deeply by the dredge than were the sandy or gravelly bottoms of Vineyard Sound.

Of the six determined species of nemerteans recorded for the Survey dredgings not one was taken with sufficient frequency to warrant our plotting a distribution chart. The species of most frequent occurrence was *Cerebratulus luridus*, which was recorded 10 times, though some of these records are regarded as doubtful. This species was taken throughout the lower half of Buzzards Bay.

The six species recorded by us from our dredgings are:

Lineus bicolor.
Micrura leidyi.
Cerebratulus lacteus.
Cerebratulus marginatus.
Cerebratulus luridus.
Amphiporus ochraceus.

5. BRYOZOA.

Of the Bryozoa, 76(+5?) determined species are recorded for the Woods Hole region of which 5 are Endoprocta, the remainder belonging to the Ectoprocta. These species are assigned to 21 families and 36(+1?) genera. Out of the total number of species recorded, 67 (+1?), or about 85 per cent, were taken during our own dredging operations; some 6 or 7 more were collected by other means during the progress of the Survey, while 5 or 6 others are included wholly upon the authority of published statements.

Several new species have been encountered during the Survey dredging, descriptions of which have been prepared by Dr. Osburn; while about 45 species have been added by us to the known fauna of the region. This latter number is considerably greater than we have been able to record for any other group of organisms, a fact which should not surprise us when we recall that no systematic study of the Bryozoa had been made in these waters within the past 30 years. Indeed, the subject has remained until recently in the same incomplete and rather chaotic condition in which it was left by Verrill. One of the authors of the present report was led to undertake the determination of the species collected during the Survey dredging. This was found to necessitate a critical examination of the literature of the group and a comprehensive study of the bryozoan fauna of our Atlantic coast, the results of which have recently been published.[a]

[a] Osburn, Raymond C.: Bryozoa of the Woods Hole region. Bulletin U. S. Bureau of Fisheries, vol. xxx, 1910 (1912), p. 203–266, pl. XVIII–XXXI.

Desor, in 1848, described two species of Bryozoa (*Bugula turrita* and *Membranipora tenuis*) which were collected by him in the vicinity of Nantucket.

Verrill, in the report upon the invertebrates of Vineyard Sound, listed 33 species of Bryozoa, of which 27 determined species and several doubtful ones were recorded for specified points within the limits of the Woods Hole region. Only one of our local species was there described for the first time. In subsequent papers Verrill added a considerable number of new Bryozoa to the fauna of the deeper waters off the American coast, but not more than 5 of these last fall within the limits embraced by the present report. Nickerson (1898) added a single species of endoproct (*Loxosoma davenporti*) to our local fauna, this being first described from specimens taken by him at Cotuit Harbor. So far as we know this is the only addition which has been made to Verrill's lists of Bryozoa down to the time of the present Survey.

Whiteaves catalogues 115 species of Bryozoa for the waters of eastern Canada. Of these species, 45 (+2?), or about 40 per cent, have been recorded from the Woods Hole region. On the other hand, these 47 species which are common to the two lists constitute nearly 60 per cent of the number comprised in our own catalogue.

The Plymouth list records the occurrence of 103(+1?) members of this group, a number which is also considerably in excess of that recorded for the Woods Hole region. About 30 per cent of the Plymouth species (about 40 per cent, therefore, of the Woods Hole species) are common to the two lists.

Herdman catalogues 136 species of Bryozoa (along with many varieties) for the Irish Sea; while Graeffe has recorded 56 species for the Gulf of Triest.

It is scarcely likely that these figures give us any accurate idea of the relative representation of this phylum in the respective areas of sea bottom. It is not at all probable that the search for these organisms has been equally exhaustive at the various points named, and it is certain that the areas explored are far from being comparable in magnitude (see p. 87). We may assert in full confidence that the extension of our own dredging operations to the 50-fathom line would have very greatly increased our list of Bryozoa.

The average number of species per dredge haul recorded for the stations of the regular series was 2.9. The species having the most general distribution was *Bugula turrita*, which was present at 255 (more than half) of the dredging stations. Those which were encountered so frequently as to be taken at one-fourth or more of the total number of stations are:

Bugula turrita (255 stations).
Crisia eburnea (201 stations).
Schizoporella unicornis (197 stations).
Smittia trispinosa nitida (163 stations).

Representatives of this group are to be found attached to almost every sort of solid object within the waters of our region. Upon stones and shells they form calcareous incrustations, which may be white, gray, yellow, or red in color, and are often many layers in thickness. Such are *Smittia trispinosa nitida* and various species of *Schizoporella*, *Membranipora*, and *Lepralia*.

Other calcareous forms (*Cellepora americana*, *Schizoporella unicornis*, and *S. biaperta*) give rise to coral-like nodules or foliaceous expansions upon Hydrozoa, algæ, or other Bryozoa. Erect, hydroid-like colonies, such as those of *Bugula*, *Bicellaria*, or *Crisia*,

attach themselves to various other fixed organisms, or directly to piles or stones. *Flustrella hispida* forms a thick matting over the rockweed along shore, and several species may be found upon active living animals, such as crabs. One, indeed, makes its home in the gill chamber of the blue crab (*Callinectes sapidus*). Various minute Bryozoa may readily be mistaken for hydroids, or may be overlooked altogether. Thus there is little doubt that many such forms escaped the collectors entirely during the earlier dredging work of the survey. With some few exceptions, the incrusting species are the ones which figure most prominently in the dredging records, colonies of this sort seldom being absent from stones or shells. Owing to the superficial similarity of several quite distinct species of incrusting Bryozoa, it was our practice throughout the dredging work to save for preservation samples of even the commonest species from every dredge haul in which they occurred. Only three species of Bryozoa (*Bugula turrita*, *Crisia eburnea*, and *Cellepora americana*) were regularly identified by the collectors in the field, and there seems to be little probability that these were confused with any less familiar forms. All other species, so far as detected, were preserved for future examination. These were later identified by Dr. Osburn, who is likewise responsible for the classification here adopted.

Charts (27–46) have been prepared showing the distribution of those species which were recorded from 10 or more of the dredging stations.[a] Two of these species, *Lepralia americana* and *L. pallasiana*, were confused in the earlier dredging records to such an extent that it has been thought best to plot their combined distributions upon a single chart. Thus there are only 20 charts for these 21 species.

Less of general interest is to be gathered from the local distribution of the Bryozoa than from that of many other groups which we have considered. Only two distinct types of distribution are to be found among those forms which have been dredged with any frequency in local waters. We have (1) species whose distribution is general, or without any definite restrictions throughout Vineyard Sound and Buzzards Bay; and (2) species found wholly, or at least predominantly, in Vineyard Sound. Not a single species has been found which appears to be restricted in any degree to the Bay. Thus the phylum has a considerably greater representation in the Sound than in the Bay. The average number of species taken per dredge haul[b] may be tabulated as follows:

Vineyard Sound:	
Fish Hawk stations	3.4
Phalarope stations	3.0
Buzzards Bay:	
Fish Hawk stations	2.7
Phalarope stations	2.0

The average number of species for the Crab Ledge stations would doubtless greatly exceed any of these figures, but unfortunately the data are not available.

It is highly probable that the character of the bottom has been the chief factor in determining the results here tabulated, just as in the case of the Hydrozoa. Reference to the table on page 79 shows that the average number of species per dredge haul for

[a] Including the supplementary stations of 1906–1909, for the same reason as already stated in the case of the Foraminifera and cœlenterates.

[b] Based upon the original stations only. Were the supplementary dredgings to be considered in this computation, it is likely that the figures for Buzzards Bay would be somewhat greater, though it is quite improbable that they would equal those for Vineyard Sound.

gravelly and stony bottoms is 3.7, that for sandy bottoms being 2.8, and that for muddy bottoms being 2.0.

The same fact is shown by an enumeration of those species which were taken at one-half or more of the dredging stations on each type of bottom. Four species (*Crisia eburnea, Bugula turrita, Schizoporella unicornis*, and *Smittia trispinosa nitida*) are recorded as present in more than half of the dredge hauls made upon gravelly or stony bottoms; a single species (*Bugula turrita*) is listed for as great a proportion of the dredge hauls upon sandy bottoms; while not a single species was found with sufficient frequency upon muddy bottoms to appear in this list.[a]

It is obvious, however, that no such bare characterization of the type of bottom properly describes the habitat of a fixed organism which depends for support upon the presence of some solid substratum. Now various solid objects, organic and inorganic, are commonly present, even upon bottoms of practically pure sand, and such objects frequently furnish attachment for Bryozoa. Even soft mud commonly contains dead shells or fragments of these, and some typical fixed organisms, such as the coral *Astrangia* and the serpulid worm, *Hydroides*, are consequently of frequent occurrence upon muddy bottoms. We believe, nevertheless, that the comparative paucity of Bryozoa upon such bottoms is due in part to the scarcity of suitable objects for attachment. Thus the relative infrequency of *Cellepora americana* and *Hippothoa hyalina* in Buzzards Bay is probably correlated with the scarcity of hydroids and algæ. On the other hand, it seems probable that the continued deposition of silt is unfavorable to the growth of many forms, even though a suitable basis of support be present.

Grouping those species which have been charted by us, according to whether their distribution is general or restricted, we may arrange them provisionally under two heads. In making this classification, the greater absolute number of dredging stations in Vineyard Sound must be taken into account.

Species having a general or unrestricted distribution in local waters.

Crisia eburnea.
Ætea anguina.
Bugula turrita.
?Membranipora pilosa.
Membranipora aurita.
Schizoporella unicornis.
Schizoporella biaperta.
Lepralia americana+pallasiana.
Lepralia pertusa.
Smittia trispinosa nitida.
Hippuraria armata.

Thus the majority of our commoner species do not appear to show any marked preference for one or the other body of water. One of the foregoing species (*Membranipora pilosa*) appears, however, to display an avoidance of the more central regions of the Bay. In the above list it will be seen that both erect and incrusting forms are included.

Species restricted wholly or mainly to Vineyard Sound.

	Number of stations.
Bicellaria ciliata	16 Sound+ 3 Bay.
Membranipora tenuis	59 Sound+17 Bay.
Membranipora flemingii	12 Sound+ 0 Bay.
Cribrilina punctata	12 Sound+ 0 Bay.
Hippothoa hyalina	26 Sound+ 7 Bay.
Cellepora americana	66 Sound+13 Bay.

[a] It must be added, however, that the lists (pp. 70, 71 above) of species present in *one-fourth* or more of the dredge hauls upon these respective types of bottom comprise about equal numbers of Bryozoa.

At least two of the foregoing species (*Membranipora tenuis* and *Hippothoa hyalina*), while occurring with some frequency in the Bay, are restricted for the most part to the neighborhood of land.

The preponderance of some of these forms in the Vineyard Sound records is probably due in part to the relative imperfection of our data for Bryozoa from Buzzards Bay. Supplementary dredgings in the Bay, during the summer of 1909, revealed the presence of a number of species not hitherto found there, and indicated that certain others were not so scarce in this body of water as had been supposed. Indeed, it has been necessary to remove certain species from this second list which had earlier been placed there. Concerning the following species it is not believed that we have sufficient data to warrant any conclusions as to their relative abundance in the Bay and the Sound:

Tubulipora liliacea.
Membranipora monostachys.
Bowerbankia gracilis.

As a matter of fact all three of these species are recorded from an absolutely greater number of stations in the Sound than in the Bay. One of them (*Membranipora monostachys*) has been recorded in the latter only from the stations near land.

Aside from the few cases mentioned, in which the occurrence of certain species in the Bay is limited to the inshore waters, there is nothing in the distribution of any of the species, so far as shown by the charts, which can be regarded as in any sense "bathymetric." Certain species which do not appear in our distribution charts, however, are restricted to shallow waters, or to the immediate neighborhood of land, and indeed may find their proper habitat in the littoral or intertidal zone. The most familiar instance of the last sort is the abundant *Flustrella hispida*, which occurs in great profusion upon the rockweeds, *Fucus* and *Ascophyllum*. Certain other species, likewise, such as *Eucratea chelata*, *Amathia dichotoma*, and *Bugula flabellata*, have seldom been encountered by us except upon piles. Another species, *Membranipora tehuelcha*, has only been noted upon the floating gulfweed, with which it is borne passively to our waters. This, like so many other species having the same habitat, is a southern form which does not properly belong to our local fauna.

Not a single instance has been found among our dredging records of a species of this group whose distribution in Vineyard Sound and Buzzards Bay appears to be determined by temperature. There dwell, however, within the outlying colder waters of the region considered by us, a considerable number of species, most of which represent a strictly northern fauna, and many of which, indeed, find in Woods Hole or vicinity their southern limit of distribution. A number of these have not previously been recorded south of Canada. A list of those species is presented, herewith, which have been taken by us at Crab Ledge or in the vicinity of Nantucket, but not within Vineyard Sound or Buzzards Bay. Data are included respecting their distribution as heretofore known.

Crisia cribraria.................Canada.
Stomatopora diastoporoides ....British Isles, Baffins Bay, Gulf of St. Lawrence.
Tubulipora atlantica...........North Atlantic from Labrador to Florida; Australia.
Tubulipora flabellaris..........Northern Atlantic and Arctic seas; Greenland, Gulf of St. Lawrence, Grand Manan; Mediterranean?
Gemellaria loricata.............Northern Atlantic and Arctic seas; Labrador, St. Georges Banks, Grand Manan.

Scruparia clavata	British Isles, Gulf of St. Lawrence.
Cellularia peachii	Northern Atlantic and Arctic seas; Labrador, Gulf of St. Lawrence, St. Georges Banks.
Menipea ternata	Northern Atlantic and Arctic seas; Labrador, Gulf of St. Lawrence, Grand Manan.
Caberia ellisii	Northern Atlantic and Arctic seas; Greenland, Labrador, Gulf of St. Lawrence, Maine.
Bugula cucullifera	Maine, off Cape Cod.
Bugula murrayana	Northern Atlantic and Arctic seas; Greenland, Labrador, Gulf of St. Lawrence, New England.
Membranipora cymbæformis	Northern Atlantic and Arctic seas; Gulf of St. Lawrence.
Membranipora craticula	Northern Atlantic and Arctic seas; Davis Strait, Gulf of St. Lawrence.
Membranipora unicornis	Northern Atlantic and Arctic seas; Greenland, Gulf of St. Lawrence, North Pacific.
Membranipora arctica	
Cribrilina annulata	"Eminently a northern form;" Spitzbergen, Greenland, Labrador, Gulf of St. Lawrence, Grand Manan.
Porina tubulosa	Northern Atlantic and Arctic seas; Gulf of St. Lawrence.
Schizoporella auriculata	Red and Mediterranean Seas to Arctic Ocean; Gulf of St. Lawrence.
Schizoporella sinuosa	Northern Atlantic and Arctic seas; Gulf of St. Lawrence.
Cellepora canaliculata	Gulf of St. Lawrence; off Halifax.
Mucronella pavonella	Northern Atlantic and Arctic seas; Gulf of St Lawrence, North Pacific.
Smittia porifera	North Atlantic and Arctic seas; Gulf of St. Lawrence, Florida, South Africa, Australia.
Porella propinqua	Northern Atlantic and Arctic seas; Gulf of St. Lawrence, Davis Strait.
Porella acutirostris	Northern Atlantic and Arctic seas; Gulf of St. Lawrence.
Porella concinna	Arctic seas to Mediterranean; Greenland, Gulf of St. Lawrence.
Rhamphostomella costata	Northern Atlantic and Arctic seas; Gulf of St. Lawrence.
Alcyonidium parasiticum	British Isles.

The following notes have been furnished by Dr. Osburn relative to differences of habitat displayed by different members of the same genus:

Crisia.

C. eburnea: Our most familiar species; abundant in shallow waters, but extending to the deepest waters of the region.

C. cribraria: Found only in the outside, colder waters.

Bugula.

B. turrita: Abundant under all conditions in the inner waters; less common in the cold waters off shore, e. g., at Crab Ledge.

B. flabellata: On piles and in shallower waters down to a few fathoms; almost wholly confined to adlittoral zone.

B. murrayana: Abundant in outer waters on stones and shells; not found in inner waters.

Membranipora.

M. cymbæformis: Common upon hydroid and other stems in outside waters.

M. pilosa: Common throughout our waters on shells and algæ; differing in the form of the zooecia, according to substratum occupied.

M. unicornis: On stones and shells in outer waters.

M. monostachys: Throughout our waters; common, usually upon very smooth surfaces, such as inside of shells, on skate eggs, carapace of Limulus, etc. It presents differences of form, according to whether it grows in inner or outer waters.

M. tenuis: Common upon stones and shells, but not in shallow waters near shore.

M. flemingii: (Much as last).

M. aurita: Common on stones, shells, and algæ, at all depths.

M. tehuelcha: Only found upon drifting gulfweed.

Cribrilina.

C. punctata: Common in Vineyard Sound and outer waters, on stones and shells.

C. annulata: Only in outer, colder waters.

Schizoporella.

S. unicornis: Everywhere, forming massive colonies; less frequent in outside waters.

S. biaperta: Throughout our waters, forming flat colonies on stones and shells, or (more frequently) forming fanlike expansions on algæ, etc.

S. auriculata: Only in outside waters.

S. sinuosa: Only in outside waters.

Hippothoa.

H. hyalina: Of general distribution on algæ, shells, stones, etc.; best developed on stems of algæ and hydroids, where it forms nodular crusts.

H. divaricata: Locally, not at all common and found only in the outer waters, though not elsewhere restricted by temperature.

Lepralia.

L. americana: Throughout our waters on stones and shells, especially in deeper waters.

L. pallasiana: On stones, shells, piles, and eel grass; of general occurrence, but more frequent in shallow waters.

L. pertusa: Of general distribution; most common on shells and pebbles.

Mucronella.

M. peachii: Occasional in Sound and in outside waters, forming flat crusts on stones and shells.

M. pavonella: In outside waters only, forming flat colonies upon stones and shells, or rising into fanlike expansions on stems of hydroids, etc.

Smittia.

S. trispinosa nitida: Of very general occurrence, growing upon all sorts of objects, and forming massive nodular crusts on stones and shells.

S. porifera: In outer waters, on stones and shells; smaller colonies sometimes taken in inner waters.

Cellepora.

C. americana: Of general distribution on stems of hydroids or algæ, forming nodules or irregular masses.

C. canaliculata: In outside waters, forming rounded, pisiform colonies on stems of hydroids, etc.

Alcyonidium.

A. verrilli: Western end of Vineyard Sound; erect and branching.

A. parasiticum: In outside waters, incrusting stems and stones; argillaceous matter combined in zoarium.

A. mytili: In various situations in inside waters, incrusting, not argillaceous.

Bowerbankia.

B. gracilis and its variety caudata: Creeping over stems of other organisms, or upon piles; occurring together.

Hippuraria.

H. armata: Of general occurrence; creeping upon stems, etc., or erect.

H. elongata: Commensal in branchial chamber or on carapace of crustacea.

The following list comprises the Bryozoa collected by us in the course of the Survey dredging. A considerable number of these species were not taken, however, at any of the regular (numbered) stations, and a good many have been recorded only from outlying points, such as Crab Ledge or the shoals to the east of Nantucket. Those species which were taken at 10 or more of the stations in Vineyard Sound and Buzzards Bay are, as usual, designated by an asterisk.

Pedicellina cernua.
Barentsia major.
Barentsia discreta.
*Crisia eburnea (chart 27).
Crisia cribraria.
*Tubulipora liliacea (chart 28).
Tubulipora atlantica.
Tubulipora flabellaris.
Stomatopora diastoporoides.
Lichenopora verrucaria.

*Ætea anguina (chart 29).
Gemellaria loricata.
Scruparia clavata.
Cellularia peachii.
Menipea ternata.
Scrupocellaria scabra.
Caberea ellisii.
*Bicellaria ciliata (chart 30).
*Bugula turrita (chart 31).
Bugula gracilis uncinata.
Bugula cucullifera.
Bugula flabellata.
Bugula murrayana.
Membranipora cymbæformis.
*Membranipora pilosa (chart 32).
Membranipora craticula.
Membranipora lineata.
Membranipora unicornis.
*Membranipora monostachys (chart 33).
*Membranipora tenuis (chart 34).
*Membranipora flemingii (chart 35).
*Membranipora aurita (chart 36).
Membranipora arctica.
Membranipora arctica armifera.
*Cribrilina punctata (chart 37).
Cribrilina annulata.
Porina tubulosa.
Microporella ciliata.
Microporella ciliata stellata.
*Schizoporella unicornis (chart 38).
*Schizoporella biaperta (chart 39).
Schizoporella auriculata.
Schizoporella sinuosa.
*Hippothoa hyalina (chart 40).
Hippothoa divaricata.
*Cellepora americana (chart 41).
Cellepora canaliculata.
*Lepralia americana (chart 42).
*Lepralia pallasiana (chart 42).
*Lepralia pertusa (chart 43).
Lepralia serrata.
Mucronella ventricosa.
Mucronella peachii.
Mucronella pavonella.
Smittia trispinosa.
*Smittia trispinosa nitida (chart 44).
Smittia porifera.
Porella propinqua.
Porella acutirostris.
Porella concinna.
Porella proboscidea.
Rhamphostomella bilaminata.
Rhamphostomella costata.
Rhamphostomella ovata.
Alcyonidium verrilli.
Alcyonidium parasiticum.
Alcyonidium mytili.
*Bowerbankia gracilis (chart 45).
Bowerbankia gracilis caudata.
Anguinella palmata.
*Hippuraria armata (chart 46).

Referring to the 21 commoner species, it has not been found possible to distinguish the majority of them, according to their range, as predominantly northern or southern. This results partly from the fact that so many of the Bryozoa are surprisingly cosmopolitan in their distribution, partly from the fact that our knowledge of their distribution in American waters is so meager. In a considerable number of instances it would appear from the few American records at our disposal that a species was predominantly northern or southern in its distribution, when reference to foreign records shows that such is not the case. Even those few species which we have here distinguished as predominantly northward or southward ranging are so designated in a purely tentative way.

Predominantly northern.

Tubulipora liliacea	Labrador to Long Island Sound.
Bicellaria ciliata	Northward on our coast to the Gulf of St. Lawrence.
Membranipora flemingii	Greenland to Vineyard Sound (recorded from Adriatic).
Cribrilina punctata	Northward on our coast to Gulf of St. Lawrence.

Predominantly southern.

Bugula turrita	Casco Bay to Florida.
Membranipora monostachys	Nantucket Sound to Beaufort, N. C.
Membranipora tenuis	Same as last.
Hippuraria armata	Same as last.

Three of the four last named species are ones which have only been listed from American waters.

Of very wide range in both directions.

Crisia eburnea	Labrador to Florida (cosmopolitan).
Ætea anguina	Cosmopolitan; upon our coast recorded from points as far south as Beaufort, N. C.
Membranipora pilosa	Greenland to Beaufort, N. C. (cosmopolitan).
Schizoporella unicornis	Greenland to Florida (Europe and Africa).
Schizoporella biaperta	Greenland to Florida (Spitzbergen, Algiers, etc.).
Hippothoa hyalina	Greenland to Florida (cosmopolitan).
Lepralia pertusa	Greenland to Florida (cosmopolitan).

Position doubtful, owing to insufficiency of data.

Membranipora aurita	Not previously recorded from America.
Cellepora americana	(?)
Lepralia pallasiana	Perhaps northern.
Lepralia americana	Known only from a small section of our coast.
Smittia trispinosa nitida	Known from only a small section of our coast (also Australia).
Bowerbankia gracilis caudata	Known only from a small section of our coast.

Thus a considerable majority of these species have either an almost unrestricted range in latitude, or a range of doubtful extent. Four have been classified as predominantly northern and an equal number as predominantly southern. If, however, our calculations had been based upon the entire list of local Bryozoa, including the many species (p. 106, 107) which were listed only from outlying points, we should have been led to regard our bryozoan fauna as being, on the whole, preponderatingly northern in its character.

6. ECHINODERMATA.

This phylum is represented in local waters by only 24(+1?) known species. Of these, 6 belong to the Asteroidea, 6 to the Ophiuroidea, 4 to the Echinoidea, and 8 (+1?) to the Holothuroidea. Eighteen of these species appear in the dredging records of the Survey, as follows: Asteroidea, 6; Ophiuroidea, 5; Echinoidea, 3; Holothuroidea, 4. Data relating to several other species have, however, been furnished by various of our Woods Hole collectors. The other records for local echinoderms are based mainly upon the published statements of Verrill and of H. L. Clark. In the classification adopted by us we have followed Dr. Clark. To this authority we are indebted for the identification of many specimens, as well as for the criticism of those portions of our manuscript which relate to the Echinodermata.

Verrill and Smith (1873) listed 19 species of echinoderms for Vineyard Sound and adjacent waters. Among these were comprised 5 species belonging to the Asteroidea,[a] 4 to the Ophiuroidea, 4 to the Echinoidea, and 6 to the Holothuroidea. To these must be added 1 holothurian (*Molpadia oolitica*), which was included doubtfully, and 1 ophiuran (*Amphiura abdita*), which was reported by Verrill only from Long Island Sound, but which has since been found in Vineyard Sound and Buzzards Bay. Disregarding the holothurian just mentioned, all of the species listed by Verrill for these waters have been taken by subsequent collectors.

Except in one questionable case, our dredging operations have added no species to the known fauna of the region. This exception is the brittle star just referred

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[a] One of these, it is true ("*Asterias arenicola* Stimpson"), is not now regarded as a distinct species, but is, as Verrill himself thought likely, identical with *A. forbesi*. The name "green starfish," by which Verrill repeatedly refers to this species, is certainly a misnomer, so far as our local specimens are concerned.

to (*Amphioplus abdita* (Verrill)), which was taken at about the same time by Mr. G. M. Gray and by our own collectors on the *Fish Hawk*, and has since been dredged by us on several occasions.[a] It appears, indeed, that this species is not uncommon in local waters, and the same has proved to be true of the holothurian *Caudina arenata*, which was previously regarded as very rare locally.

Reference to the comparative table on page 88 shows that the phylum of Echinodermata is very poorly represented in the Woods Hole region, as compared with each of the other localities which have been considered. For the phylum as a whole we have the following figures: Woods Hole, 24(+1?); Eastern Canada, 71; Plymouth, 36; Irish Sea, 35; Triest, 37.

In the case of the Asteroidea and Ophiuroidea in particular, these figures are uniformly higher for the other stations than for Woods Hole. Again, our own list is the only one among them which is completely lacking in crinoids, for even *Antedon* has not thus far been met with in our waters.

Fourteen of our 24 echinoderms are common to Whiteaves's list for eastern Canada, while only 2 (perhaps only 1) are common to the Plymouth list.

In making any comparisons between these faunal lists, the usual allowance must be made for the widely different areas to which they relate, as well as to the widely different ranges in depth. Comparisons with Plymouth or with Trieste appear to be much fairer than with either of the other regions, so far as area is concerned.

The average number of species of echinoderms dredged at the 458 regular stations of the Survey was 1.9. The species which was encountered with greatest frequency was *Asterias forbesi*, which was recorded from 206 of the stations. The only ones which were recorded from as many as one-fourth of the total number of stations are:

	Number of stations.
Asterias forbesi	206
Echinarachnius parma	170
Arbacia punctulata	156
Henricia sanguinolenta	118

Owing to the comparatively large size of most members of this phylum, and to the very limited number of species which occur in local waters, it seems likely that our list of echinoderms is particularly complete. If additions are made subsequently, it will probably be among the ophiuroids and the holothurians, some of which are of small size and given to burrowing or to concealment in crevices of stones, etc. It is likely, too, that our dredging records for this group are fairly free from errors of omission or confusion of one species with another. Reference should be made, however, to certain mistakes of identification, which we believe to have been made at first.

(1) It is probable that during the early days of the work the younger specimens of *Asterias vulgaris* and *A. forbesi* were sometimes confused in the field. So far as this confusion may relate to Vineyard Sound, the results can not be serious, since our later and more accurate exploration of the Sound has shown that both species occur throughout practically its entire length. As regards Buzzards Bay, specimens of *Asterias vulgaris* were recorded from five stations within its interior, which it has been decided to leave out of consideration in plotting the distribution chart for this species. The records have,

[a] See Clark, in Science, Jan. 24, 1908, and Sumner, in American Naturalist, May, 1908. According to Dr. Clark, Mr. Gray's specimen was taken in August, 1907 (exact date not stated). Our own first specimen was dredged on Aug. 6, 1907. Here, then, is a most perplexing question of priority!

however, been retained in the list of stations for this starfish, as given in our catalogue, though their doubtful nature has been indicated. Supplementary dredgings were made in Buzzards Bay during two subsequent seasons, partly for the purpose of testing this feature in the distribution of *Asterias vulgaris*. Out of a total of nearly 60 stations, starfishes of this genus were recorded for 11. These were in all cases assignable to *Asterias forbesi*, with the exception of a few small specimens of *A. vulgaris* taken at two stations situated near the island shores and not far from the mouth of the Bay. Accordingly we regard the occurrence of the latter species in the interior portions of Buzzards Bay as being extremely doubtful.

(2) Doubt has been cast upon our earliest field identifications of the ophiuroids. For this reason, it has been regarded as fairer to bring together the records for the first year, except such as are based upon authoritative determinations, under the heading "ophiuroids unidentified." Such specimens were probably in most cases referable to the species *Amphipholis squamata*.

Distribution charts have been plotted for seven species of echinoderms (charts 47 to 53).[a] It will be seen at a glance that only two of these species (*Asterias forbesi* and *Arbacia punctulata*) were encountered with any frequency in Buzzards Bay, while of these two the former alone was generally distributed throughout the central portions of the Bay. *Arbacia* and certain other species (notably *Henricia*) were found to be largely restricted, in Buzzards Bay, to the immediate neighborhood of land. For these facts, as for similar ones already discussed in our treatment of other groups, we believe that the character of the bottom is chiefly responsible. Most of our commoner local echinoderms prefer bottoms of gravel or sand to ones of mud. To this statement, it is true, exceptions are offered by some of the holothurians and ophiuroids.

From the table on page 79 it will be seen that the average number of species of echinoderms per dredge haul, taken upon bottoms of gravel and stones, is 2.2; that for sandy bottoms being 2.0, and that for muddy bottoms being only 1.2. The different classes, however, do not agree in these preferences. The figures both for holothuroidea and ophiuroidea are greatest for muddy bottoms; but, owing to their infrequent occurrence in the dredge hauls, they do not seriously affect these averages.

The relative wealth of the echinoderm fauna upon different types of bottom is shown in another way by an enumeration of the species which were taken in one-fourth or more of the dredge hauls made upon bottoms of each type (p. 70, 71). In the list for sandy bottoms are comprised 2 asteroids and 2 echinoids; in that for gravelly and stony bottoms, 2 asteroids and 1 echinoid; in that for muddy bottoms, a single asteroid and no echinoids. Similarly, 3 asteroids and 2 echinoids appear in the list of species (p. 65) taken at one-fourth or more of the *Fish Hawk* stations in Vineyard Sound, while only 1 asteroid and no echinoids appear in the corresponding list for Buzzards Bay. The lists for the *Phalarope* stations in the two bodies of water do not show as great differences, since the conditions in the "adlittoral" region are more nearly similar throughout, but the preponderance is nevertheless somewhat in favor of Vineyard Sound.

A species which is restricted more than any other to bottoms of pure sand[b] is the "sand dollar," *Echinarachnius parma*. Character of the bottom, rather than tempera-

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[a] In the case of the charts for shell-bearing organisms, the occurrence of living specimens at a given station has been indicated by a circle surrounding the star. Among the echinoderms this practice has been followed only in the case of the two sea urchins, *Arbacia* and *Strongylocentrotus*, these being the only ones which would be likely to leave behind enduring remains. It has been assumed for these two that all the field records relate to living specimens unless the contrary is expressly stated.

[b] The dead tests are of more general occurrence, owing probably to the fact that they may be drifted by tidal currents.

ture, is probably responsible for the greater prevalence of this species in the western half of Vineyard Sound, where, as we have pointed out elsewhere, certain typical sand-dwelling species find their most congenial habitat.

On the other hand, certain less frequent species (not among those charted) were dredged chiefly upon muddy bottoms. Particularly worthy of mention is the holothurian *Caudina arenata*, which was taken by us seven times in Buzzards Bay and only once in Vineyard Sound.

The part played by temperature in determining distribution is rather strikingly illustrated by some members of our echinoderm fauna. The local distribution of the two commoner species of *Asterias* is quite in keeping with what we know of the ranges of these two forms upon our coast. A glance at charts 48 and 49 shows us that whereas *Asterias forbesi* has a practically unrestricted distribution in local waters, *A. vulgaris*, on the contrary, is most prevalent in the colder portion of Vineyard Sound. Indeed, there is seen to be a progressive concentration of the distribution symbols as we pass from the eastern to the western end of the Sound, while in the Bay the records are confined to the neighborhood of the open ocean. It is likewise worth noting in this connection that the latter species was recorded from all seven of our regular dredging stations at Crab Ledge, while *Asterias forbesi* was recorded but once.

As stated by Clark, the range of the latter species upon our coast is from "Maine to the Gulf of Mexico," but it is said to be "rare or local north of Cape Ann." It is primarily a shallow water form, which does not appear to pass beyond depths of 25 or 30 fathoms. *A. vulgaris*, on the other hand, ranges from Labrador to Cape Hatteras, though it is "rarely seen in shallow water * * * south of the Woods Hole region." It is recorded from depths as great as 358 fathoms.

Such natural expectations as to distribution in local waters are not, however, realized in the case of another starfish, *Henricia sanguinolenta*. This species, also, is listed as "littoral only as far south as the Woods Hole region," while, to the northward, it extends to Greenland. The dredging records show it to be abundant throughout the length of Vineyard Sound and, indeed, to be rather commoner in the eastern (warmer) half. It is likewise recorded from scattered stations in Buzzards Bay, even well toward its head. For this species, then, temperature seems to be a minor factor in determining the distribution in local waters.

Of considerable interest are the relative distributions of our two local sea urchins, *Arbacia punctulata* and *Strongylocentrotus droebachiensis*. The former species appears to be of general occurrence throughout Vineyard Sound, except for the portion adjoining the open ocean. In Buzzards Bay it occurs as far as the upper end, but it seems here to be restricted largely to the vicinity of land. *Strongylocentrotus*, on the other hand, occurs in greatest abundance in the western portion of Vineyard Sound, though occasional specimens have been taken as far eastward as West Chop. In Buzzards Bay it is found only near the extreme lower end. Again, *Strongylocentrotus* was taken at all seven of the stations at Crab Ledge, while *Arbacia* was not found there once. The latter species occurs locally at all depths, even up to the low-water mark. The former species, on the other hand, is rarely if ever taken at such slight depths, except in northern waters.[a] We have very few records of its occurrence in less than 5 fathoms,

[a] Verrill, it is true, states that this species occurs "at low water on the outer rocky shores." This can not be a common occurrence locally, however.

and in the great majority of cases (72 per cent) it was taken at depths greater than 10 fathoms.[a]

Comparing the range of these two species upon our coast, we find that *Arbacia* is said to occur from "Nantucket Shoals and Woods Hole to west Florida and Yucatan" (Clark), i. e., our region lies at its northern limit of distribution. The range of *Strongylocentrotus*, on the other hand, is said to be "circumpolar; southward in the western Atlantic to New Jersey (not in shallow water south of Cape Cod)."

That *Arbacia* is not adapted to enduring temperatures lower than those generally prevailing in our local waters during the winter months is indicated by the fact that a large proportion of these urchins seem to have been exterminated in Vineyard Sound during the winter of 1903–4. This winter was an extremely severe one, the ice being greater in quantity and lasting longer than for many years previously. Even Woods Hole passage, where the tidal currents are extremely swift, was frozen over so firmly that Mr. Vinal Edwards accomplished the astonishing feat of walking over to Nonamesset Island. Reference to the temperature tables for the Woods Hole station (p. 47) shows that the mean water temperature for January and February, 1904, was 29.3° F., as compared with 32.3°, the mean of these two months for the other four years comprised in the table.

Now the sudden and extreme scarcity of *Arbacia* in Woods Hole Harbor and elsewhere in the summer of 1904 was noted by local collectors generally, and we are informed by the curator of the Marine Biological Laboratory, Mr. George M. Gray, that this species did not for several years resume anything like its former abundance in local waters.[b]

Fortunately we are in possession of definite data on this subject, based upon a comparison of our dredging records for the summers of 1903 and 1904. As has been stated on page 55, a considerable number of the 1903 stations were repeated in the following summer for the sake of comparisons and verifications. In the two parallel columns below we present the records for *Arbacia*, obtained during these two seasons, in that part of the Sound (the eastern two-thirds) in which the stations were duplicated:

1903.	1904.
	7521bis (fragments and spines).
7522 (many living).	7522bis (none).
7523 (several living).	7523bis (1 spine).
7524 (very abundant, living).	7524bis (none).
7526 (2).	
7529 (few).	
7530 (abundant).	7530bis (none).
7531 (1 dead).	7531bis (few fragments).
7532 (many).	7532bis (few spines).
7533 (few, many spines).	7533bis (1 small living).
7534 (numerous).	7534bis (few spines).
7535 (few shells, many spines).	7535bis (many spines).
	7536bis (many spines).
7537 (many, rather small).	7537bis (none).
	7538bis (spines and fragments).
7539 (few).	7539bis (none).
7540 (few).	

[a] This despite the fact that hardly more than a third of our stations were in waters as deep as that.

[b] In 1908 and 1909 we were able to obtain large quantities of these urchins in Vineyard Sound by means of tangles.

1903.	1904.
7541 (few).	7541bis (many spines).
	7542bis (several spines).
7543 (fragment).	7543bis (none).
7545 (numerous living).	7545bis (fragment of shell and many spines).
7546 (few living).	7546bis (spines).
	7547bis (several living and fragments).
7549 (many living).	7549bis (few fragments and spines).
7550 (fragments).	7550bis (few spines).
7551 (few living).	7551bis (1 living, several fragments).
7552 (few).	7552bis (few spines).
	7553bis (few spines).
7554 (1 small dead).	7554bis (none).
7555 (numerous).	
7556 (few).	7556bis (many fragments and spines).
7557 (1 shell).	
7558 (many living).	
7559 (few living).	
7561 (about 2 bushels).	
7562 (few living).	7562bis (none).
7563 (many living).	7563bis (spines and fragments).
7564 (many living).	7564bis (many spines).
7566 (many spines).	
7567 (many spines).	
7568 (many spines).	
	7569bis (spines).

Thus in 1903 the presence of living specimens is expressly recorded in 12 out of 36 stations at which *Arbacia* occurred, and it is certain that they were present at many of the other stations, perhaps in all cases where the contrary is not explicitly stated. Such records as "few," "many," or "2 bushels" certainly refer, for the most part, to living specimens. We may state confidently, therefore, that living sea urchins of this species, sometimes in large numbers, were taken at from one-half to two-thirds of the stations in question. In 1904, on the other hand, living specimens (never in large numbers) were recorded from only 3 of the 23 stations at which *Arbacia* or its remains were taken. In all other cases the records are for spines and fragments.[a] Furthermore, this condition was equally manifest during the succeeding season. Stations 7735 to 7757 (dredged in 1905) cover practically the same region of the Sound as stations 7521 to 7569. At these 23 stations of the later year spines (in one case fragments) are recorded in 12 cases; in not a single case was a living *Arbacia* taken. Reference to the complete station list for this species shows that throughout the Sound as a whole (stations 7678 to 7783) living specimens of *Arbacia* were taken but 5 times during the summer of 1905, and that never more than 2 (in four cases a single one) were taken at one time.[b]

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[a] The number of records for spines only would have been somewhat greater, it is true, during the summer of 1903, had the sand, etc., brought up by the dredge, been searched as carefully that year as during subsequent seasons.

[b] It is to be noted in the case of *Strongylotrotus*, likewise, that a large proportion of the later (1905) records (7678 to 7752) indicate the presence of spines and fragments only, while living specimens alone were noted in 1903. This last circumstance was, however, doubtless due in considerable measure to the fact that the loose spines of the green urchin were overlooked during the first season (see preceding footnote). The absolute number of stations from which living specimens are recorded in 1905 (counting as living all those not listed as "fragments" or "spines") was 8, as compared with 10 during the summer of 1903. Moreover, at 4 out of 5 of the "bis" stations (1904) at which this species was taken the records indicate living specimens. Thus it seems unlikely that *Strongylocentrotus* was unfavorably affected during the winter which wrought such havoc with *Arbacia*. The same may be said of the "sand dollar," *Echinarachnius*. We find no evidence of any destruction of this species at that time.

How the severe cold prevalent during the winter under consideration could have resulted in the death of organisms dwelling in several (sometimes many) fathoms of water is difficult to see. With animals so situated an actual freezing seems to be out of question, and the temperature to which they were subjected on this occasion was only a few degrees lower than that ordinarily endured by them in the winter. Furthermore, it must be pointed out that the peculiarities in the local distribution of *Arbacia* correspond to known differences in summer temperatures, not winter temperatures. As has been shown above (p. 50), it is likely that in winter all our waters attain practically the same temperature at the coldest period of the year; and indeed it is the shallower, more inclosed waters, such as those frequented by *Arbacia*, which are the ones to respond most quickly to the winter cold. Further consideration will be given to this subject in chapter v (p. 177).

In addition to these illustrations, which have been discussed at length, we find several other instances among this group of species whose distribution in local waters is certainly related to temperature. Thus *Asterias austera*, *Solaster endeca*, and *Gorgonocephalus agassizii*, which reach their southern limit of distribution in this region, have been taken by us only at Crab Ledge; while *Asterias tenera*, though recorded from points as far south as New Jersey, is predominantly a northern form, and locally is only known from outlying points such as Crab Ledge and Sankaty Head. Again the brittle star *Ophiopholis aculeata* and the peculiar little holothurian *Thyone unisemita*, the first of which, at least, is known to be a predominantly northern form, have only been recorded by us from the western end of Vineyard Sound and from Crab Ledge—a not unusual combination, as we have seen.

Although it is a problem to what degree depth, as such, can be regarded as a factor in determining the distribution of marine animals, we find of course many species which appear to show marked preferences for the deeper or the shoaler waters of the region. Among the echinoderms, it has already been pointed out that the sea urchin *Strongylocentrotus* occurs in Vineyard Sound chiefly at depths of 10 fathoms or more. The same is true to a less extent of *Asterias vulgaris*.[a] Now both of these have already been mentioned as northern forms, which are restricted in large measure to the colder waters of the region. Their avoidance of the shoaler waters near land is probably dependent upon their preference for lower temperatures.

Some of our local holothurians have a converse type of distribution; i. e., they show a decided preference for extremely shallow waters. To what degree this fact is related to temperature, and to what degree it depends upon the character of the bottom, in which they burrow, need not be considered here. One of this group, *Thyone briareus*, was dredged by us several times but never far from land, and its more characteristic habitat is probably in waters which are not accessible to the dredge at all.

The following is a list of the echinoderms which were taken by us in the course of the Survey dredging. The asterisk denotes as usual those species which were encountered at 10 or more stations in Vineyard Sound and Buzzards Bay, and for which, consequently, distribution charts have been plotted.

[a] To a certain degree *Henricia sanguinolenta* is more prevalent in the deeper waters. Only 7 per cent of our records for this species are from depths less than 5 fathoms, although 24 per cent of all our stations were at depths not exceeding that figure.

Solaster endeca.
*Henricia sanguinolenta (chart 47).
Asterias austera.
*Asterias forbesi (chart 48).
Asterias tenera.
*Asterias vulgaris (chart 49).
Ophioderma brevispina.
Ophiopholis aculeata.
*Amphipholis squamata (chart 50).
Amphioplus abdita.
Gorgonocephalus agassizii.
*Strongylocentrotus droebachiensis (chart 51).
*Arbacia punctulata (chart 52).
*Echinarachnius parma (chart 53).
Cucumaria pulcherrima.
Thyone briareus.
Thyone unisemita.
Caudina arenata.

Considering the 7 more prevalent species of local echinoderms, we may group them, as usual, according to their range upon our coast, as predominantly northern or southern. The distributions here stated are those given by Clark.

Predominantly northern.

Henricia sanguinolenta............"Greenland and Labrador to Connecticut, off New Jersey and even Cape Hatteras."
Asterias vulgaris..................."Labrador to Cape Hatteras; but south of the Woods Hole region rarely seen in shallow water."
Strongylocentrotus droebachiensis.."Circumpolar; southward in the western Atlantic to New Jersey (not in shallow water south of Cape Cod)."

Predominantly southern.

Asterias forbesi...................."Maine to the Gulf of Mexico, rare or local north of Cape Ann."
Arbacia punctulata................"Nantucket Shoals and Woods Hole to West Florida and Yucatan."

Of uncertain position.

Amphipholis squamata............Arctic Ocean to West Indies and South America. (Australia; Mediterranean Sea.)
Echinarachnius parma.............On our coast, from Labrador to New Jersey (also Red Sea).

It is obvious that no fair opinion can be formed regarding the zoogeographical position of our local echinoderms from a consideration of these few species. According to Clark, 5 of the 6 true starfishes of the region are northern, though the Asteroidea are the only group which show this preponderance of northern forms.

7. ANNULATA AND SIPUNCULIDA.

ANNULATA.

Of the Annulata proper 148 determined species are recorded, to which number must be added 4 undetermined species and a few others which are doubtfully to be included in this list. These species represent 109 genera and 40 families. Of the total number of species recorded, 83, or more than 50 per cent, were taken during our own dredging operations; 46 others are recorded for local waters on the authority of persons who have participated in the work of the Survey, while 30 species are included wholly on the authority of published statements. The great majority of the segmented worms here recorded belong to the subclass Polychæta, of which about 135 species have been listed for the region. In addition to these, however, are 11 species of Oligochæta and 4 of the Hirudinea.

Only a single new species (*Arabella spinifera* Moore) has been described from specimens taken during the Survey dredging. A number of species hitherto unrecorded locally have, however, been added to the known fauna of the region. Such are *Myxicola steenstrupii*, *Pista intermedia*, *Polycirrus phosphoreus*, *Spiochætopterus oculatus*, *Spirorbis*

tubæformis, and some or all of the following:[a] *Amphitrite cirrata, Chætinopoma greenlandica, Cirratulus cirratus, Glycera capitata* and *Praxilella zonalis*.

Verrill and Smith (1873) listed 70 determined species of Annulata from specified localities lying within the limits of our region, and some 5 others whose range, as stated, would include Woods Hole and vicinity. Our present list thus comprises about twice as many representatives of this phylum as were catalogued for the region in the "Report upon the Invertebrate Animals of Vineyard Sound." More than 20 other determined species, however, were recorded at that time by Verrill for adjacent portions of the Atlantic coast; while in later papers he added many more to the fauna of the Woods Hole region itself. Most of those species of our own list which are not comprised within the various papers of Verrill have been recorded upon the authority of Dr. J. P. Moore, who has devoted some years to a systematic study of the Woods Hole Polychæta. Some of these, as above stated, were first taken during the survey dredging operations, while a yet greater number were collected independently by Dr. Moore before the latter operations were commenced. It is understood that Dr. Moore has noted the occurrence of a number of species which are not included in this report, but these records are unfortunately not available at present. Except in the case of certain familiar and easily determined forms, all of the annelids from the dredging collections were identified by the last-named zoologist, to whom we are likewise indebted for the revision of our check list of species. This authority is also responsible for the terminology adopted, though not, of course, for all the statements in the text.

Our list of Annulata considerably exceeds that given by Whiteaves for eastern Canada. Of the 105 Polychæta comprised in the latter catalogue, 29, or somewhat more than one-fourth, appear to be common to the Woods Hole region. None of the other groups of segmented worms have been considered by Whiteaves.

The total number of annelids listed in the Plymouth catalogue is surprisingly near to that in our own. The number of Polychæta is somewhat greater (148) in the former; the number of Oligochæta being smaller (only 3). Of the Plymouth Annulata, 10 of the Polychæta and 1 of the Oligochæta appear to be common to Woods Hole.

Herdman has listed 90(+2?) members of this phylum for the Irish Sea; while Græffe records 142 species for the Gulf of Trieste.

Certain defects of method must be taken into account in judging of the completeness of our dredging records for the annelids. As is well known, a large proportion of the species burrow in the sand or mud, in some cases quite deeply. When disturbed, they retreat hastily from the surface. In order to obtain such forms without mutilation, or in many cases even to obtain fragments of them, it is necessary to dig deeply into the soil. Dredges such as those employed in the present work removed, at best, but a few inches from the surface of the mud and sand, giving the burrowing worms an ample opportunity to escape.

An impressive instance of the incompleteness of our records for some of these burrowing annelids is furnished by the case of *Diopatra cuprea*. This species, as is well known, constructs a parchment-like tube, extending down some feet into the ground. The terminal, exposed portion of the tube is reinforced by any small bits of solid matter which happen to be at hand, e. g., pebbles, shell fragments, or bits of eel grass. By the exercise of considerable care the living worm may be dug up in shallow water. But

[a] These species were all dredged during the course of the survey. Whether or not they had previously been collected independently by Dr. Moore is not known.

although we have encountered these tubes (or rather short segments of tubes) at 198 stations throughout Vineyard Sound and Buzzards Bay, we have not a single record of having taken even the anterior portion of the worm itself in the course of our dredging. Our records for *Chætopterus pergamentaceus*, *Clymenella torquata*, *Melinna maculata*, and the two species of *Pista* likewise relate almost exclusively to tubes; although the first two of these species, at least, may be readily collected by digging in shallow water. It is highly probable also that some small and inconspicuous species were pretty constantly lost or overlooked in the process of washing large quantities of mud or sand, particularly as we were seldom assisted in the field by anyone having an adequate knowledge of this group.[a]

Mistakes due to the actual confusion of one species with another in the field records are probably particularly infrequent for the annelids, in as much as nearly all of the specimens were reserved for identification by Dr. Moore. The one known case in which a certain degree of confusion exists is that of the small tube-dwelling worms of the genus *Spirorbis*. It was not at first realized that several species of closely similar appearance existed within the limits of the region dredged, and for this reason it was not thought necessary to save samples from every dredge haul. It has consequently been found necessary to list a considerable proportion of our specimens merely as "*Spirorbis* sp. undetermined;" and it has not seemed worth while to present the distribution charts for any members of the genus, although at least one of these (*S. tubæformis*) is known to have been taken at more than 10 stations.

On the average, 4.3 species of Annulata were recorded for each of the Survey dredge hauls. The species found to have the most general distribution was *Hydroides dianthus*, which was taken at 223 of the 458 stations. Those encountered so frequently as to be taken at one-fourth of the total number of stations were:

Hydroides dianthus (223).
Diopatra cuprea (198).
Nereis pelagica (192).
Harmothoë imbricata (189).
Lepidonotus squamatus (165).

As might have been readily inferred from the habits of this group of organisms, the character of the bottom was found to be the dominant influence in determining their distribution. Now, we have seen that the bottom of Buzzards Bay, as a whole, is muddy, whereas most portions of Vineyard Sound, however much they differ in other respects, agree in the scarcity of mud. Accordingly we find it possible to divide the majority of the annelids from the Survey dredgings into predominantly Bay-dwelling and predominantly Sound-dwelling forms.

As judged by our dredging records, members of this phylum are encountered with considerably greater frequency in Buzzards Bay than in Vineyard Sound.[b] The average number of species taken per dredge haul for each body of water and for each vessel may be tabulated as follows:

Vineyard Sound:	
Fish Hawk stations	3.5
Phalarope stations	4.6
Buzzards Bay:	
Fish Hawk stations	6.2
Phalarope stations	4.6

[a] To obtain satisfactory results, portions of the bottom material should be covered with sea water and left standing in dishes for some hours.

[b] This statement is in no way inconsistent with the fact that the total number of species recorded for the Sound as a whole is considerably greater than that recorded for the Bay (p. 80).

It is to be noted that this preponderance in favor of the Buzzards Bay stations relates only to those of the *Fish Hawk.* It is in the deeper portions of the Bay, where the *Fish Hawk* dredgings were made, that the mud predominates. Elsewhere the bottom agrees more closely with that of Vineyard Sound.

These same facts are shown by a comparison of the lists of "prevalent" species for the different groups of stations (p. 65–71), i. e., the lists of those species which were taken at one-fourth or more of the stations belonging to each group. Thus the list for the *Fish Hawk* stations of Vineyard Sound contains five species; that for the *Fish Hawk* stations of Buzzards Bay, nine species. The list for the *Phalarope* stations in Vineyard Sound contains five species; that for the *Phalarope* stations of Buzzards Bay, six species.

With reference to the wealth of annelid life upon the three types of bottom which we have considered, we have the following figures, representing the average number of species per dredge haul: Sand, 3.4; stones and gravel, 4.7; mud, 5.2.

To what extent the greater wealth of annelid life upon muddy bottoms is actual and to what extent it is apparent can not be stated. Soft mud is of course cut into much more deeply with the dredge than is sand or gravel, and thus a larger proportion of the burrowing worms would be collected from the former type of bottom, even if they were equally common upon both.

Those species which were taken in one-fourth or more of the dredge hauls made upon sandy bottoms are: [a]

Harmothoë imbricata.
Nereis pelagica.
Diopatra cuprea.
Hydroides dianthus.
Lepidonotus squamatus.

It will be seen that this list comprises exactly the same species as were recorded for one-fourth or more of the total number of stations. It likewise comprises the same species as are to be found in the lists for both the *Fish Hawk* and *Phalarope* stations in Vineyard Sound.

The following is a list of prevalent species (according to the same standard) taken upon bottoms of gravel and stones:

Hydroides dianthus.
Nereis pelagica.
Lepidonotus squamatus.
Harmothoë imbricata.
Diopatra cuprea.
Pseudopotamilla oculifera.

The only one of these which was not comprised in the preceding list is the last one named.

The corresponding list for muddy bottoms is as follows:

Hydroides dianthus.
Diopatra cuprea.
Nephthys incisa.
Clymenella torquata.
Harmothoë imbricata.
Ninoë nigripes.
Cistenides gouldii.

Three of the foregoing species (*Hydroides*, *Diopatra*, and *Harmothoë*) were comprised in all of the preceding lists, and indeed they may be regarded as almost ubiquitous in local waters. The other four are to be regarded as characteristic of muddy bottoms, and indeed all of the seven appear among the "prevalent" species for the *Fish Hawk*

[a] In this and all similar lists, the species are arranged in the order of frequency.

stations in Buzzards Bay. The latter list is seen to be the most extensive one, so far as annelids are concerned. It will be found upon p. 66 and need not be repeated here.

Distribution charts (54–82) have been prepared for those 29 species (exclusive of *Spirorbis*) which were taken at 10 or more dredging stations. With respect to their distribution in local waters, we may arrange the species in the five following groups:

Species nearly or quite restricted to Vineyard Sound.

	Number of stations.
Eulalia annulata	17 Sound+[a] 1 Bay.
Lepræa rubra	22 Sound+ 1 Bay.
Polycirrus eximeus	10 Sound+ 0 Bay.

These species and some less frequent ones which might have been included are recorded almost exclusively from bottoms of sand or gravel. It is perhaps worth noting that the three listed are ones which are found most commonly in the interstices of the sandy ascidian, *Amaroucium pellucidum*. *Polycirrus eximeus* is recorded by us only from the eastern half of the Sound.

Species occurring predominantly in Vineyard Sound, though more or less common in Buzzards Bay.

	Number of stations.
Harmothoë imbricata	122 Sound+60 Bay.
Lepidonotus squamatus	113 Sound+44 Bay.
Nereis pelagica	152 Sound+23 Bay.
Lumbrineris hebes	15 Sound+ 5 Bay.
Pseudopotamilla oculifera	59 Sound+18 Bay.
Sabellaria vulgaris	60 Sound+12 Bay.

Reference to the charts shows that in the case of four of these six species, their occurrence in Buzzards Bay is in a large degree restricted to the inshore stations. This is a type of distribution which has been met with frequently, being exemplified by animals belonging to nearly all phyla. The comparative scarcity of mud at these inshore stations of the Bay is doubtless responsible for this peculiarity in their distribution.

Species nearly or quite restricted to Buzzards Bay.

	Number of stations.
Nephthys incisa	46 Bay+3 Sound.
Ninoë nigripes	38 Bay+1 Sound.
Rhynchobolus americanus	22 Bay+2 Sound.
Chætopterus pergamentaceus	43 Bay+0 Sound.
Spiochætopterus oculatus	35 Bay+2 Sound.
Pista intermedia [b]	18 Bay+2 Sound.
Melinna maculata	16 Bay+0 Sound.
Cistenides gouldii	37 Bay+0 Sound.
Maldane elongata	16 Bay+0 Sound.

Species occurring predominantly in Buzzards Bay, though taken occasionally in Vineyard Sound.

	Number of stations.
Pista palmata [b]	23 Bay+ 7 Sound.
Ampharete setosa	15 Bay+ 5 Sound.
Clymenella torquata	50 Bay+10 Sound.
Trophonia affinis	17 Bay+ 4 Sound.

[a] At mouth of Bay. [b] Mostly inshore stations.

With a very few exceptions the last two lists comprise species which primarily inhabit muddy shores and bottoms. In the case of certain species (*Clymenella* and *Rhynchobolus*) it is to be noted that the few records of their occurrence in Vineyard Sound refer to areas whose bottoms are known to be partially muddy. This type of distribution is not, however, wholly intelligible in the case of *Clymenella torquata*, since it is known to occur in abundance in shores of pure sand. Unlike most of the foregoing species, *Pista palmata* and *P. intermedia* appear to be restricted, both in the Bay and in the Sound, to the adlittoral zone. They are found upon various types of bottom, including muddy ones. *Platynereis megalops* might perhaps have been included in the last of the foregoing lists, since it was recorded more frequently (absolutely as well as relatively) from Buzzards Bay. Like the two species of *Pista*, it was taken much more often at the inshore stations.

As the last of our groups with respect to distribution, we have:

Species exhibiting no evident preference for one or the other body of water.

	Number of stations.
Nephthys bucera	6 Sound + 5 Bay.
Marphysa leidyi	7 Sound + 5 Bay.
Diopatra cuprea	105 Sound + 86 Bay.
Arabella opalina	27 Sound + 17 Bay.
Parasabella microphthalmia	6 Sound + 6 Bay.
Hydroides dianthus	130 Sound + 93 Bay.

The distribution of most of these last species seems to be entirely independent of the character of the bottom. Two of them (*Diopatra* and *Hydroides*) are among the most ubiquitous of our local Annulata, though it is possible that the distribution of *Diopatra* is not so general as the wide-spread occurrence of its tubes would lead one to suppose. Regarding three of the foregoing species the records are too meager to permit of our forming any conclusions of value. *Nephthys bucera* is probably not of general occurrence in the Bay, since it is known to be predominantly a sand-dwelling species.

The temperature factor, which has been shown to be such an important one in determining the distribution of many species belonging to other groups of organisms, probably applies to certain of the local annelids, though it appears to play a relatively insignificant part with respect to the species for which charts have been plotted. The only case among the latter which seems to fall under this head is that of the serpulid worm *Hydroides dianthus*. The absence of this species from the western portion of Vineyard Sound is a conspicuous feature in its distribution, especially when coupled with the fact that it has not once been recorded from Crab Ledge, despite the favorable bottom at the latter point. It is of probable significance in this connection that *Hydroides* is predominantly a southward-ranging species, which may, on this account, be poorly adapted to the colder waters of the region. The case resembles that of the coral *Astrangia* (p. 99) and that of the sea urchin *Arbacia* (p. 113), which have already been discussed from this point of view. So far as our records go, however, there are in Vineyard Sound none of those characteristic cold-water species which are confined to the neighborhood of the open ocean. But there are a number of species of annelids recorded from the Crab Ledge stations alone among the dredgings of the survey. For most of such species Cape Cod is believed to lie at the southern limit of distribution. Some of these are included in the following table. The statements as to range have been furnished us by Dr. Moore.

Northern types taken only at Crab Ledge.

Ammotrypane fimbriata	Gulf of Maine to Vineyard Sound.
Amphitrite cirrata	Northern Europe to Crab Ledge.
Chætinopoma greenlandica	Northern seas, south in deep water to Massachusetts.
Eunoë oerstedi	Greenland to Vineyard Sound.
Filograna implexa	North Atlantic, south to Nantucket; off Sankaty Head.
Glycera capitata	Northern Europe to Crab Ledge.
Nothria conchylegia	North Atlantic, south to Cape Cod.
Myxicola steenstrupii	North Atlantic, south to Massachusetts.
Thelepus cincinnatus	North Atlantic, south to Massachusetts.

The low temperature of the bottom waters at Crab Ledge was considered on p. 51 and has been referred to elsewhere in our discussions of distribution.

Attention has already been called to the fact that a number of our charted species of annelids are recorded primarily from the inshore (adlittoral) stations, both in the Bay and in the Sound. This is true of *Pista palmata*, *Pista intermedia*, *Parasabella microphthalmia*, and in a lesser degree of *Platynereis megalops*. The same phenomenon is exhibited by certain less common species, such as *Sthenelais picta* and *Dodecaceria coralii*. All of these species were recorded wholly or chiefly from the *Phalarope* and *Blue Wing* stations.

On the other hand, certain species appear at first sight to show a tendency exactly the opposite of that manifested by those just mentioned. These others were encountered with considerable frequency during the *Fish Hawk* dredging, but were seldom taken by the *Phalarope*. Examples of such species are *Eulalia annulata*, *Nephthys bucera*, *Ninoë nigripes*, *Arabella opalina*, and *Rhynchobolus americanus*. As a matter of fact, however, the last two species, at least, are known to be common along shore, where they may be dug up with the spade. Their absence from the *Phalarope* records is very probably due to the failure of the dredges employed on the latter vessel to cut deeply enough into the bottom. Indeed, it is quite possible that this same explanation will hold for most of the cases in which species of Annulata seem to be restricted to the *Fish Hawk* stations.

And, in general, when we are considering any case in which a given species has been obtained almost exclusively by one or the other vessel, the question must be asked whether the personal element may not have played a part in determining this result. It has been stated that the *Fish Hawk* and *Phalarope* dredgings were under the supervision of different persons. As is well known, different observers see different things, depending upon what has especially been brought to their notice. We do not believe however, that much importance need be attached to this source of error in considering most of the species which have been listed here. In the case of certain of those which have been mentioned as having a predominantly adlittoral habitat (e. g., *Pista intermedia*), it is noteworthy that even the *Fish Hawk* stations at which they were taken were mainly near shore.

A considerable number of the Annulata, the names of which appear in our faunal catalogue, are strictly intertidal in their habitat, or at least are confined to the shallow waters just below the tidal limits. Such forms have naturally not been taken with the dredge, although many of them are common enough in their proper habitat. Examples of species such as these are *Podarke obscura*, *Nereis limbata*, *Scoloplos fragilis*, *Amphitrite ornata*, *Notomastus luridus*, *Arenicola cristata*, *Arenicola marina*, *Spirorbis spirorbis*,

and all of the Oligochæta so far as listed. As has already been stated, it is likely that most of the benthic species extend nearly or quite up to the littoral zone; and indeed they often occupy the latter as well.

On the other hand, many of our local Annulata are pelagic during a part, at least, of their existence. This is true of the larvæ of nearly all the Polychæta, and holds for the sexual phase of many adult worms, particularly the Syllidæ and Nereidæ. One highly modified and typically pelagic form, *Tomopteris helgolandica*, is taken in the local tow during the winter and spring, sometimes occurring in abundance. Two exotic species, which may perhaps be termed pelagic, were found upon floating timbers among goose barnacles. These are *Amphinome pallasii*[a] and *Hipponoë gaudichaudi.*

A few of the more striking examples of a difference of habitat being shown by different members of the same genus are as follows:

Nephthys.
- N. incisa: Frequents bottoms of soft mud.
- N. bucera: Frequents sandy bottoms.

Nereis.
- N. pelagica: Clear waters, non-muddy bottoms.
- N. limbata: Strictly littoral, preferring foul and brackish waters.
- N. virens: Diverse habitat.

Cirratulus.
- C. grandis: Shores and deeper waters in sand and gravel.
- C. parvus: Deeper waters only, in colonies of Amaroucium pellucidum.

Amphitrite.
- A. ornata: Inner waters of region, strictly littoral.
- A. brunnea and A. cirrata: Only recorded from Crab Ledge.

Pista.
- P. palmata: Said to frequent purer waters and cleaner sand than P. intermedia.

Spirorbis.
- S. spirorbis: On rock-weed, littoral.
- S. tubæformis: On Phyllophora and Chondrus, from adlittoral zone to greatest depths of region.
- S. quadrangularis: At Crab Ledge only.
- S. stimpsoni: At Crab Ledge only.
- S. fewkesi: From algæ in deeper waters of Vineyard Sound.

The following species of Annulata were taken during the dredging operations of the Survey:

Autolytus ornatus.
Eusyllis fragilis.
Odontosyllis lucifera.
Pædophylax dispar.
Syllis pallida.
Trypanosyllis sp.
*Eulalia annulata (chart 54).
Eulalia gracilis.
Eulalia pistacia.
Eumidia americana.
Phyllodoce catenula.
Eunoë oerstedi.
*Harmothoë imbricata (chart 55).
*Lepidonotus squamatus (chart 56).
Lepidonotus sublevis.
Sigalion arenicola.
Sthenelais gracilis.
Sthenelais picta.
*Nephthys bucera (chart 57).
*Nephthys incisa (chart 58).
Nereis arenaceodentata.
Nereis dumerilii.
*Nereis pelagica (chart 59).
Nereis virens.
*Platynereis megalops (chart 60).
*Marphysa leidyi (chart 61).
*Diopatra cuprea (chart 62).
Nothria conchylegia.
*Arabella opalina (chart 63).
Drilonereis longa.

[a] This, we learn, is known to be littoral in the West Indies.

*Lumbrineris hebes (chart 64).
Lumbrineris tenuis.
*Ninoë nigripes (chart 65).
Euglycera dibranchiata.
Glycera capitata.
*Rhynchobolus americanus (chart 66).
Scoloplos fragilis.
Scoloplos robustus.
Polydora concharum.
Scolecolepis viridis.
Spio sp. undet.
*Chætopterus pergamentaceus (chart 67).
*Spiochætopterus oculatus (chart 68).
Ammochares artifex.
Cirratulus cirratus.
Cirratulus grandis.
Cirratulus parvus.
Cirratulus tenuis.
Dodecaceria coralii.
Amphitrite cirrata.
*Lepræa rubra (chart 69).
Nicolea simplex.
*Pista intermedia (chart 70).
*Pista palmata (chart 71).
*Polycirrus eximeus (chart 72).
Thelepus cincinnatus.
Sabellides pusilla.
*Ampharete setosa (chart 73).
*Melinna maculata (chart 74).
*Cistenides gouldii (chart 75).
Capitella sp.
Ammotrypane fimbriata.
Ophelia denticulata.
*Clymenella torquata (chart 76).
*Maldane elongata (chart 77).
Praxilella zonalis.
Scalibregma brevicauda.
Brada setosa.
*Trophonia affinis (chart 78).
Euchone elegans.
Myxicola steenstrupii.
*Parasabella microphthalmia (chart 79).
*Pseudopotamilla oculifera (chart 80).
Protula sp.
Chætinopoma greenlandica.
Filograna implexa.
*Hydroides dianthus (chart 81).
Spirorbis quadrangularis.
Spirorbis spirillum (probably taken more than ten times).
Spirorbis tubæformis.
*Sabellaria vulgaris (chart 82).
Ichthyobdella funduli.

If we classify our 30 commoner species of bottom-dwelling annelids as predominantly northern or southern, according to their known range upon our coast, we have the following groups:[a]

Predominantly northern.

Harmothoë imbricata	Circumboreal; south on our coast to New Jersey.
Lepidonotus squamatus	Both sides of North Atlantic; Greenland to South Carolina: also reported from north Pacific.
Nephthys incisa	Spitzbergen to Long Island Sound.
Nereis pelagica	Greenland and Labrador to Beaufort, N. C., becoming smaller and less common south of Vineyard Sound.
Ninoë nigripes	Eastport, Me., to Block Island.

Predominantly southern.

Eulalia annulata	Provincetown, Mass., to New Jersey.
Nephthys bucera	Massachusetts Bay to Charleston, S. C.
Platynereis megalops	Cape Cod to Beaufort, N. C.
Marphysa leidyi	Massachusetts to North Carolina.
Diopatra cuprea	Cape Cod to Charleston, S. C.
Arabella opalina	Massachusetts to Porto Rico.
Rhynchobolus americanus	Massachusetts to Charleston, S. C.
Chætopterus pergamentaceus	Cape Cod to West Indies.
Spiochætopterus oculatus	Wellfleet, Mass., to Virginia.
Lepræa rubra	Massachusetts to North Carolina.
Pista palmata	Cape Cod to Virginia.

[a] The ranges are stated upon the authority of Dr. Moore.

Polycirrus eximeus............Cape Cod to Beaufort, N. C
Ampharete setosa..............New Haven to east of Falmouth.
Melinna maculata..............Woods Hole to Virginia.
Cistenides gouldii..............Casco Bay to North Carolina.
Clymenella torquata............Eastport, Me., to Porto Rico.
Maldane elongata...............Massachusetts to North Carolina.
Trophonia affinis................Massachusetts Bay to southern New Jersey.
Parasabella microphthalmia....Massachusetts Bay to Beaufort, N. C.
Hydroides dianthus............Casco Bay (in sheltered places) and Massachusetts Bay to Charleston, S. C.
Spirorbis tubæformis...........Vineyard Sound to New Haven.
Sabellaria vulgaris..............Provincetown to Beaufort, N. C.

Having a range of approximately equal extent north and south.

Lumbrineris hebes ....Casco Bay to New Jersey.
Pseudopotamilla oculifera......Bay of Fundy to Virginia.

Of doubtful position.

Pista intermedia...............Cape Cod to Block Island.

It will thus be seen that a large majority of the more prevalent benthic species of Annulata found in this vicinity are predominantly southern in their range, while of the few species whose range is predominantly northern all but two have a range which extends far to the southward of Woods Hole.

SIPUNCULIDA.

So far as known, this group of worms has a scant representation in our local fauna. Only three determined species are included in our list, of which only one (*Phascolion strombi*) was encountered with any frequency in the dredge. This was mainly recorded from the inshore stations of Buzzards Bay, though taken elsewhere on a number of occasions (chart 83). On account of its peculiar mode of life it was probably frequently overlooked during the earlier days of our dredging. This worm, according to Gerould, is "found all along the eastern coast of North America from off Virginia northward to Labrador." Since it occurs in such widely different latitudes as the West Indies and the northern coast of Asia, the distribution of this species can have little relation to temperature.

Another of our local sipunculids (*Phascolosoma verrillii* Gerould) has been taken on a very few occasions only. It was apparently observed by Verrill, though not described by him.

8. ARTHROPODA.

With a few exceptions the phylum Arthropoda is represented in our marine fauna by the class Crustacea alone, the members of which occupy somewhat the same position in the life of the sea as do the insects upon land. The total number of Crustacea thus far listed for this region is about 300, which is a larger number than is recorded for any other class of animals or even for any entire phylum besides the Arthropoda. There are comprised in our catalogue 289 definitely determined species of Crustacea, together with 3 which are undetermined and 18 which have been determined with doubt. Of these, 126(+6?) are to be assigned to the subclass Entomostraca and 163(+15?) to the subclass Malacostraca. Since the former subclass comprises for the most part small

and inconspicuous forms, it is likely that the list of these is far less complete than that for the latter group, which comprises, for the most part, species of moderate or large size. It is the Malacostraca, likewise, which are chiefly represented in our dredging records; indeed, we should say *exclusively* represented but for the ever-present barnacles.

Owing to the magnitude of this class and to the fact that different sections have been treated by different specialists, it seems best to consider the orders separately.

I. PHYLLOPODA.

The Phyllopoda are represented in our list by two members of the Polyphemidæ, which were identified by Mr. R. W. Sharpe among material collected with the townet at Woods Hole, and by a species of *Artemia*, which was observed by Verrill in "salt vats" at Falmouth, and is perhaps not to be included in our marine fauna at all. One or more species of Polyphemidæ are at times excessively abundant in the Woods Hole plankton, and it is likely that our phyllopod fauna is far more extensive than the present meager records would imply.

II. OSTRACODA.

Twenty-six species of ostracods have been identified by Dr. Cushman[a] among specimens collected in the vicinity of Woods Hole. Of these, 21 were recorded from the Survey dredgings. Since this group had never been studied locally prior to the work of Dr. Cushman, all of these 26 species may be regarded as additions made to our local fauna through the operations of the Survey. Ten of them were described for the first time by Dr. Cushman from specimens dredged or otherwise collected during the summer of 1905.

Mr. R. W. Sharpe, who has examined large quantities of townet material collected in Woods Hole Harbor, believes that he has met with "perhaps 20 forms, certainly new to our shores, and mostly new to science." Thus far, however, he has not published descriptions of any of these local species.

Reference to the comparative table on page 88 shows that 29(+9?) species of ostracods have been listed for eastern Canada, 6 for Plymouth, 57(+1?) for the Irish Sea, and 9 for the Gulf of Trieste. It is likely that these numbers represent the relative thoroughness of the search which has been made for these organisms rather than the relative wealth of species at these points. Ten of the Canadian species are known to be common to Woods Hole, but so far as we may infer from the lists there are no species common to Woods Hole and Plymouth.

None of the Ostracoda were recorded from a sufficient number of dredging stations to warrant our plotting distribution charts for them. Moreover, they were only sought for during one season of the regular dredging work of the Survey[b] and consequently we have a very imperfect idea of their distribution in local waters. From our records the ostracods appear to be chiefly restricted to the western end of Vineyard Sound, and it seems likely that their scarcity in the eastern part is in a considerable measure real, since bottom samples from the entire length of the Sound were examined by Dr. Cushman.

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[a] A list of these has already been published in Proceedings of the Boston Society of Natural History, vol. 32, 1906.

[b] A few additional records were obtained in 1907.

III. COPEPODA.

These fall into two rather natural subdivisions, including the free-living and the parasitic forms, respectively, though the line of division is not strictly a taxonomic one. The list of free-living copepods, including 25 (+1?) species, is derived from the published reports of W. M. Wheeler (1900) and of R. W. Sharpe (1910).[a] Wheeler listed 30 species for the "Woods Hole Region," though the majority of these were recorded only from waters lying well without the limits of the region considered in the present report. Mr. Sharpe examined collections taken by himself in the tow net throughout the season of 1908, as well as material which had already been gathered by the schooner *Grampus* and by Mr. V. N. Edwards. He has catalogued 60 species, of which, however, more than half are extralimital.

The parasitic copepods of this region, of which 58(+2?) species are comprised in our catalogue, have been listed by S. I. Smith (in Verrill and Smith, 1873), R. Rathbun (1884–1887), M. J. Rathbun (1905), and by C. B. Wilson in a series of recent papers. We are indebted to the last-named authority for examining the manuscript of our annotated list of this group, as well as for furnishing a valuable set of notes which have been incorporated in the latter. The nomenclature and the classification adopted are his.

Scarcely any copepods, either free or parasitic, are recorded in the Canadian catalogue of marine invertebrates. The Plymouth list comprises 24 free-living species and one parasitic. Herdman has listed 195 copepods (chiefly free-living) from the Irish Sea, while Graeffe's catalogue for the Gulf of Trieste includes 56 free-living copepods and 110 parasitic species. Here again, it is quite unlikely that these figures are at all indicative of the actual wealth of the copepod fauna at the respective points.

IV. CIRRIPEDIA.

Of this order, 17 species are listed for the region, though two of these are included somewhat doubtfully. Of these only two (*Balanus eburneus* and *B. porcatus*), and possibly a third (*B. crenatus*), have been taken during our Survey dredging. Most of the species listed in the catalogue have, however, been collected at one point or another by our parties. One species, *Chthamalus stellatus*, although very abundant at present, seems to have escaped the notice of local zoologists and had not apparently been recorded for New England waters until attention was recently called to it by one of the present writers.[b] Another (*Balanus tintinnabulum*) had not, so far as we know, been definitely recorded for points within the region. This last is, however, an exotic form, and is not, probably, to be included in our fauna.

Verrill and Smith (1873) listed 13 species of barnacles, most of which, however, were not recorded from definitely indicated points within the limits of our region. All but one of our 17 species are included by Miss Rathbun in her "List of the Crustacea," though not in all cases recorded for strictly local waters.

Scant attention has been given, however, to the sessile barnacles of our coast, and it is not unlikely that further studies will considerably increase the number of known species. Notwithstanding this probable incompleteness of our list, it will be seen

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[a] The list of Rhode Island species prepared by Williams (1906) has not been considered here, since the records relate only to Narragansett Bay.

[b] Science, Sept. 17, 1909. (See also footnote on page 190 of this report.)

(p. 89) that a greater number of cirripedes have been catalogued from Woods Hole than from any of the other stations considered in our table. Only 10 species each have been listed by Whiteaves, Herdman, and the Plymouth laboratory, while 15 have been recorded by Graeffe. Six of the Canadian species and 4 of those listed for Plymouth are common to our Woods Hole catalogue.

The barnacles, particularly the sessile forms, are a very baffling group to the taxonomist, and it must be admitted that our local collections have not received the treatment which they deserve. During the greater part of the Survey dredging separate specimens were preserved from each station at which barnacles were taken. A large proportion of these specimens were immature, many others were waterworn and imperfect. The small collection made during the summer of 1903 was examined by Dr. H. A. Pilsbry, who furnished a list of identifications covering this earlier period. The survey was unable to obtain the services of this specialist in determining the barnacles dredged during the subsequent seasons of the work.[a] This task was finally undertaken by the senior author of this report, who offers his results with considerable reservation. Attention must be called to the frequently reiterated statements of Darwin, the chief monographer of this group, respecting the high variability and the indefinite limits of the species of *Balanus*. As evidence of the impossibility of distinguishing these species by external characters, he writes (Monograph of the Cirripedia, vol. II, p. 187): "After having described nearly 40 species, and when my eye was naturally able to appreciate small differences, I began carefully to examine varieties of *B. tintinnabulum, amphitrite, improvisus, porcatus, vestitus*, etc., without even a *suspicion* that they belonged to these species, at that time thoroughly well known to me." It must be added, however, that the case is far less difficult to one who deals with a very few species occupying a very limited area. Unless certain species which have never been reported from the Woods Hole Region are nevertheless common here, our determinations are probably correct in the great majority of cases.

By far the larger proportion of specimens coming from the Survey dredgings which have been examined have been referred to *Balanus eburneus*. Large specimens of this species, found upon the bottom of a boat and elsewhere, have been studied carefully, with reference both to the internal and external structure of the shell. The same careful examination was extended to certain of the specimens coming from the dredgings. None of the latter, however, nearly equaled in size the examples taken from woodwork in shallow water, and are probably for the most part immature. The longitudinal striation of the terga is faintly indicated, or altogether wanting, and the general shape of the opercular plates differs from those taken from adult specimens. It must be confessed, therefore, that general appearance and the process of elimination have led us to our decision in regard to most of these specimens. They are obviously not to be referred to *Balanus balanoides*, for they have a shelly base, and differ in other conspicuous ways. Moreover, the latter species is strictly intertidal in its habitat. Nor are they to be assigned to *Balanus crenatus*, *B. porcatus*, or, indeed, to any of the other species which have thus far been recorded from this region. At least one source of serious confusion seems to be possible, however. Darwin tells us that "diagnosis

[a] We are indebted to him, however, for the identification of a considerable number of stalked barnacles of the genera *Lepas* and *Conchoderma*.

is most difficult without long practice" between immature specimens of *B. eburneus* and the young of *B. improvisus*. According to both Darwin and Gruvel, the latter species is recorded from Nova Scotia and the coast of the United States, though no definite localities are stated. Thus it does not seem unlikely that this species occurs in our local waters and that it may have hitherto been confused with *Balanus eburneus*. Barring this possibility, however, of a confusion with some closely similar species which has not been recorded from local waters, it is probable that nearly all of the barnacles dredged by the Survey are to be assigned to *Balanus eburneus*. Acting upon this supposition, we have plotted out a single distribution chart based not only upon the specimens which have been identified as *Balanus eburneus* but upon those which, owing to immaturity or poor preservation, could not be identified with confidence. The two sets of records have, however, been separated in the faunal catalogue.

The chart (84) shows us that this species is of general occurrence and of considerable abundance throughout both the Sound and the Bay. It was recorded from 157 stations, or somewhat more than one-third of the total number dredged. The specimens which were dredged were commonly attached to stones or shells, very frequently to shells which were occupied by hermit crabs. This last circumstance may account, in some measure, for the very general distribution of this species upon the local sea floor. *Balanus eburneus* occurs at all depths within our region, even extending up to the neighborhood of the low-water mark, where its zone overlaps that of *B. balanoides*.[a]

The range of *Balanus eburneus*, according to Darwin, is from Massachusetts ("about lat. 42°") to Venezuela and the West Indies. It thus falls within the class of southward-ranging species.

Barnacles of one (perhaps two) other species were dredged by us. Large specimens of *Balanus porcatus* were taken at Crab Ledge, and at least one specimen of this same species was taken in Vineyard Sound. Other worn shells, which are believed to be those of either *B. porcatus* or *B. crenatus*, were dredged on several occasions in the Sound. The latter species was said by Verrill to be "abundant" in Vineyard Sound, but this is directly contradicted by our own experience, though we have found it growing in considerable numbers upon piles at Vineyard Haven.

Above low-water mark *Balanus balanoides* occurs in prodigious profusion, being one of the most abundant and conspicuous members of our littoral fauna. With it upon rocks and piles, though commonly at a somewhat higher level, is to be found *Chthamalus stellatus*, which is likewise abundant and generally distributed along our shores locally.

A number of species of stalked barnacles of the genera *Lepas* and *Conchoderma* are included in our list. Several of these species, notably *Lepas fascicularis*, *L. hilli*, and *L. anatifera*, are sometimes found in considerable profusion. They are, however, pelagic organisms which find their proper home in the open sea.

[a] We have found *Balanus balanoides*, *B. eburneus*, *B. crenatus*, and *Chthamalus stellatus* growing together on a single piece of bark removed from a wharf pile at Vineyard Haven.

V. AMPHIPODA.

Locally, at least, the amphipods are by far the most abundant of the Malacostraca, both in respect to the number of individuals and of species. Seventy-one determined species are recorded for the region, to which number must be added 6 which are listed as undetermined or are doubtfully to be included in this list. These species belong to 54(+5?) genera and 22(+2?) families. Of the total number of species recorded, 35, or about one-half, have been taken during our own dredging operations; 26 others have been identified from shore or townet collections made during the progress of the survey; while the remainder are recorded solely upon the authority of published statements.

None of the species encountered during the present work have been described as new to science, though it is believed that the collections contain one or more undescribed species. About nine species have been added to the fauna of the region either through our dredging operations or through the identification of material in the possession of the laboratory.

Verrill and Smith (1873) listed 31 species of amphipods, of which only 16 were determined species recorded for specified localities within the region. Many of the others must, however, have been observed in local waters, although the ranges were stated in general terms.

Holmes (1905) lists 79 determined species of amphipods, some of which were first described in his report of that date. From this number, however, must be deducted about 20 species which were not recorded for points within the area at present under consideration. Miss Rathbun, in her "List of the Crustacea," includes over 100 species and varieties for the whole of New England, but a considerable proportion of these are extralimital as regards our present region.

The list of invertebrates for eastern Canada comprises 70(+4?) species of amphipods, a number almost identical with our own. Of these, 20 are known to be common to the two lists. The Plymouth catalogue records 52 members of this order, of which only 7 or 8 appear to be common to our Woods Hole fauna. Herdman catalogues 129 species for the Irish Sea, while Graeffe lists 49(+1?) for the Gulf of Trieste.

Since the amphipods are contained very largely in the sand and mud brought up by the dredge, the completeness of the record for any region depends, of course, upon the character of the bottom sample obtained and upon the thoroughness with which it is subsequently washed. Thus in the first season (1903) few amphipods were listed, owing to the imperfect methods then employed. Another possible source of error is the likelihood of free-swimming species from any depth being caught in the dredge during the passage of the latter through the water after leaving the bottom. Thus, some of those amphipods which constitute at times such an important element in the plankton may figure as bottom dwelling species in the records. It is believed that cases of this sort are comparatively few, however, owing to the probability that these free-swimming species would pass out through the meshes of a dredge net.

With a few exceptions no effort was made to identify the amphipods in the field, but the specimens from each station were preserved for future determination. For the identification of many of these we are under obligation to Prof. S. J. Holmes, to whom we are likewise indebted for a critical examination of our check list of amphipods. The greater part of the work of identification was, however, performed by Dr. Cole. A

large collection of specimens taken by Mr. Edwards with the tow net, or gathered by the Survey parties during the shore collecting, has been identified for us by Dr. B. W. Kunkel. A few of the readily recognizable forms (e. g., *Unciola irrorata*) were frequently listed in the field. Unfortunately during the first season all the Caprellidæ were recorded by the collectors as "*Caprella geometrica*." Since some other members of this genus have been recorded from the region, and particularly since the allied *Æginella longicornis* is found with great frequency, such records are, of course, equivocal, and they have been changed to "Caprellidæ sp." Later dredgings have, however, resulted in differentiating to some degree the distributions of these species, but not sufficiently to warrant our plotting out a separate chart for each. We have consequently prepared a single chart showing their combined distribution.

On the average 1.6 species of amphipods are recorded for each of the Survey dredge hauls. The species found to have the most general distribution was *Unciola irrorata*, which was taken at 115 of the regular dredging stations. No other member was encountered at as many as one-fourth the entire number of stations.

The most salient fact respecting the distribution of the bottom-dwelling amphipods in local waters is the paucity of species in Buzzards Bay as compared with Vineyard Sound. In fact, of the 19 species for which distribution charts have been plotted, only 2 are shown to be of greater abundance in the Bay, while not more than 2 others seem to be present in about equal numbers in the two bodies of water. We may for convenience group the species as follows with reference to their comparative abundance in one or the other body of water.

Species wholly or chiefly restricted to Vineyard Sound.

	Sound stations.	Bay stations.
Lysianopsis alba	11	2
Haustorius arenarius	11	1
Byblis serrata	16	4
Calliopius læviusculus	15	0
Pontogenia inermis	25	2
Batea secunda	24	1
Gammarus annulatus	9	1
Elasmopus lævis	30	3
? Autonoë smithi (data too few)	12	5
Amphithoë, rubricata	32	9
Jassa marmorata	16	1
Ericthonius minax	31	1
Corophium cylindricum	59	7
Æginella longicornis / Caprella geomtrica	78	7

Species chiefly restricted to Buzzards Bay.

Ampelisca macrocephala	4	27
Ptilocheirus pinguis	14	42

Species of nearly unrestricted distribution.

Ampelisca spinipes	32	23
Unciola irrorata	70	40

With the exception of those four species comprised in the last two lists, the amphipods, when recorded from Buzzards Bay at all, were nearly always taken in the vicinity of land, i. e., at the adlittoral stations. In a large proportion of cases the Bay stations were near the passages connecting with Vineyard Sound, or close to the lower end of the Bay.[a]

On the other hand, even within the Sound, certain species are found not to have an unrestricted distribution. For example, *Haustorius arenarius*, *Byblis serrata*, *Calliopius læviusculus*, *Pontogenia inermis*, and *Jassa marmorata* are in large degree restricted to the western half of the Sound, while *Lysianopsis alba*, *Batea secunda*, and *Autonoë smithi* are for the most part restricted to the eastern half. One of the two predominantly Bay-dwelling species (*Ampelisca macrocephala*) and perhaps also the other (*Ptilocheirus pinguis*) appear to be in some measure restricted in the Sound to points where the bottom is muddy. The difference between the Bay and the Sound in respect to tneir amphipod faunas, and in considerable measure the local distribution within each of these bodies of water, are for the most part explainable by reference to the character of the bottom. Just such types of distribution have already been encountered in the case of other groups and need not be discussed here. Certain cases which appear to be explainable by reference to temperature will be considered shortly.

An interesting feature respecting the amphipod life of the Bay and the Sound appears when we consider the average number of species taken per dredge haul for each body of water and for each vessel. The figures are as follows:

Vineyard Sound:	
Fish Hawk	1.8
Phalarope	1.9
Buzzards Bay:	
Fish Hawk	1.3
Phalarope	1.1

While these figures were considerably higher for the Sound stations than forthe Bay stations, there is nothing like the disproportion which might have been expected in view of the fact that the number of predominantly Sound-dwelling species which were shown upon our charts was so much in excess of (7½ times) the number of predominantly Bay-dwelling species.

Again, the average number of species per dredge haul is the same (1.6) for each of the three types of bottom distinguished. And when we consider the lists of "prevalent" species for the various groups of stations, we find that only such one (*Unciola irrorata*) occurred at one-fourth of the Vineyard Sound stations of the *Fish Hawk*, while three species (*Ptilocheirus pinguis*, *Unciola irrorata*, and *Ampelisca macrocephala*) occurred at an equal proportion of Buzzards Bay stations. This condition seems to be only explainable on the supposition that while the number of species which inhabit Vineyard Sound is greatly in excess of the number found in Buzzards Bay, such species as do occur in the latter are of much more general prevalence throughout its extent. A discussion of similar phenomena has already been given in chapter III.

Two apparent cases of distribution in relation to temperature are *Calliopius læviusculus* and *Pontogenia inermis*, which occur, so far as our dredging records show, primarily

[a] In some cases, just without. Here and elsewhere stations have been classed as Bay or Sound stations which lay on the Bay or Sound sides, respectively, of Sow and Pigs Reef, extending from the end of Cuttyhunk Island.

in the colder region of the Sound. Both of these are predominantly northern species, as will be seen by reference to the table on page 135, giving the ranges of some of the local amphipods. It must be added, however, that the first species is taken throughout the year in the surface tow at Woods Hole and has been collected along shore at various local points even in midsummer. In the case of two other species, *Byblis serrata* and *Haustorius arenarius*, there appears to be likewise to some extent a preference for the western extremity of Vineyard Sound. Neither of these, so far as known, are predominantly northern species, and it is likely that the character of the bottom is the determining factor in their distribution, particularly since *Haustorius* is known to be abundant on sand flats near shore. Its preference for the western portions of the Sound is thus comparable with that of the lady crab, *Ovalipes ocellatus*. A few species, on the other hand, appear from our rather meager records to occur predominantly in the warmer waters of the region. Such are *Lysianopsis alba*, *Batea secunda*, and *Autonoë smithi*. All of these have been recorded only for the immediate neighborhood of Woods Hole, and their general distribution is unknown. Little stress is to be laid upon any of these cases, however, especially since a number of other species which here reach their northern or their southern limit are distributed locally without any apparent reference to temperature.

Amphithoë rubricata alone, among those species whose distributions have been plotted with any degree of completeness, seems to be restricted to the littoral and adlittoral zones. It is recorded chiefly from the inshore stations dredged by the *Phalarope* and *Blue Wing*, and the comparatively few *Fish Hawk* stations at which it was taken are all in the neighborhood of land.

The following amphipods were recorded during the Survey dredging, those taken at 10 or more stations being designated as usual by an asterisk:

?Talorchestia megalophthalma (perhaps not from bottom).
Anonyx nobilis (generic name questionable).
*Lysianopsis alba (chart 85).
*Haustorius arenarius (chart 86).
Phoxocephalus holbolli.
Paraphoxus spinosus.
*Ampelisca macrocephala (chart 87).
*Ampelisca spinipes (chart 88).
*Byblis serrata (chart 89).
Stenothoë minuta.
Sympleustes latipes.
*Calliopius læviusculus (chart 90).
*Pontogenia inermis (chart 91).
Dexamine thea.
*Batea secunda (chart 92).
Gammarus locusta.
*Gammarus annulatus (chart 93).
*Elasmopus lævis (chart 94).
Gammarellus angulosus.
Microdeutopus danmoniensis.
*Autonoë smithi (chart 95).
*Ptilocheirus pinguis (chart 96).
Podoceropsis nitida.
*Amphithoë rubricata (chart 97).
Amphithoë longimana.
Sunamphithoë pelagica.
Ischyrocerus anguipes.
*Jassa marmorata (chart 98).
Grubia compta.
Ericthonius rubricornis.
*Ericthonius minax (chart 99).
*Corophium cylindricum (chart 100).
*Unicola irrorata (chart 101).
*Æginella longicornis } (chart 102, "Caprellidæ sp.").
*Caprella geometrica }

The 19 commonest species of amphipods are herewith grouped with reference to their known range upon our coast. The ranges stated are those given by Holmes (1905).

Northward ranging.

Ampelisca macrocephala	Off Halifax to Newport.
Calliopius læviusculus	Greenland to Narragansett Bay.
Pontogenia inermis	Arctic Ocean to Vineyard Sound.
Ptilocheirus pinguis	Labrador to New England.
Amphithoë rubricata	Labrador to Newport.
Unciola irrorata	Greenland to New Jersey.
Æginella longicornis	Greenland to Narragansett Bay.

Southward ranging.

?Haustorius arenarius	Cape Cod to Georgia, Norway, British Isles.
Elasmopus lævis	Provincetown, Mass., to New Jersey.
Ericthonius minax	Vineyard Sound to Great Egg Harbor, N. J.
Corophium cylindricum	Provincetown, Mass., to New Jersey.
Caprella geometrica	Southern coast of New England to Virginia.

Of uncertain position.

Lysianopsis alba	Woods Hole.
Ampelisca spinipes	Long Island Sound, Woods Hole. (Norway.)
Byblis serrata	Woods Hole, Newport.
Batea secunda	Woods Hole.
Gammarus annulatus	Vineyard Sound, Gloucester.
Autonoë smithi	Vineyard Sound and Buzzards Bay.
Jassa marmorata	Woods Hole region.

Thus there seems to be a slight excess of northern over southern species among those 19 amphipods which we have dredged most frequently. Little importance is to be attributed to this fact, however, in considering which element is preponderant in our fauna, particularly since for more than one-third of these commoner species the range is not known with any degree of completeness.

VI. ISOPODA.

This order is represented in the local fauna by 25 or more species, of which 10 were recorded from our dredging stations and at least 7 more were taken by collectors from the laboratory during the progress of the Survey. One of these (*Erichsonella attenuata*) is here recorded for the first time for this region.

Our knowledge of this group in New England waters is due chiefly to the labors of O. Harger and Dr. Harriet Richardson. To the latter authority we are indebted for the identification of some of our earlier specimens, though the greater part of the material was determined by Dr. Osburn. The nomenclature employed by Miss Richardson has been adopted by us without modification.

Twenty-one species of isopods were listed by Harger in the "Invertebrate Animals of Vineyard Sound," of which only a small proportion were at that time recorded for definitely stated points within the limits of the region. In a later paper (1880) the group was treated much more fully by this writer.

The Canadian list of Whiteaves records about the same number of isopods (26) as have been listed for Woods Hole. Of these, nearly half (12) are common to the two lists. A somewhat greater number (30) is comprised in the Plymouth list, of which only 5 appear to be common to our local fauna. Twenty-four species have been recorded by Herdman for the Irish Sea, while Graeffe lists 51 species, some of which, however, are terrestrial.

The representation of this order in our dredgings is very slight. The figure representing the average number of species per dredge haul is only 0.4, while not a single species was taken with sufficient frequency to occur at one-fourth or more of the stations. The species having the widest occurrence was *Idothea phosphorea*, which was taken at 72 of the regular stations.

Only four species of this order were dredged by us with any frequency, and one of these (*Idothea baltica*) probably finds its more proper habitat among rockweed and eelgrass, whether growing alongshore or floating at the surface. It is thus possible that all of the specimens which were dredged by us actually came from floating material of this sort.[a]

One of the other species, *Leptochelia savignyi* was only taken at 11 stations, and these were all inshore stations of the *Phalarope* series. The species is abundant among floating weed, upon piles, etc., and probably does not belong to our deeper water fauna.

The two remaining species (*Idothea phosphorea* and *Erichsonella filiformis*) appear with considerable frequency in our dredging records. Of these the latter appears to be of pretty general distribution, occurring with nearly the same relative frequency in the Bay and the Sound, while the former is in a large degree restricted to the Sound, appearing in the Bay records only from stations near the lower end, in the vicinity of land.[b]

Isopods dredged by the Survey.

*Leptochelia savignyi (chart 103).
Cirolana concharum.
Chiridotea cæca.
Idothea metallica.
*Idothea baltica (chart 104).
*Idothea phosphorea (chart 105).
Edotea acuta.
Edotea montosa.
*Erichsonella filiformis (chart 106).
Stegophryxus hyptius.

Of the four commoner species, one (*Idothea phosphorea*) may be regarded as predominantly northern, having a range upon our coast which is stated by Miss Richardson as "coast of New England to Halifax, Nova Scotia, and the Gulf of St. Lawrence."

Two of the species may be regarded as predominantly southern, as follows:

Leptochelia savignyi..........Provincetown, Mass., to southern New Jersey (England to Senegal).
Erichsonella filiformis.........Nantucket Sound to Florida and the Bahamas.

One of the species (*Idothea baltica*) may be regarded as cosmopolitan, having been recorded from points as widely removed as Java and the Baltic Sea. On our coast it is said to range "from Nova Scotia and Gulf of St. Lawrence to North Carolina."

[a] Miss Richardson gives the bathymetric range of this species as "surface to 119 fathoms."
[b] Our 1909 dredgings confirm these statements as to both species.

VII. SCHIZOPODA, CUMACEA, STOMATOPODA.

Little attention has been given to the local representatives of the first of these groups since the work of S. I. Smith in 1879. The majority of the determined species of Schizopoda in our list are included solely upon the authority of Prof. Smith and of Miss Rathbun. Schizopods teem in the local plankton at certain seasons of the year, and specimens are occasionally taken in the dredge, though it is not at all certain that such specimens are actually brought up from the bottom. Only one species from our dredging collections (*Nyctiphanes norvegica*) has been definitely identified, since we have unfortunately been unable to find anyone who would undertake the task of determining our local Schizopoda. It will be seen that this order has a greater representation in each of the foreign lists which have been summarized in our comparative table. In the Plymouth list, indeed, the number is nearly five times as great.

Members of the order Cumacea are rather common in the Woods Hole plankton, and have occasionally been met with during the dredging. Dr. W. T. Calman (1912) has recently prepared a report upon the Cumacea of the U. S. National Museum. Eight of these species are recorded from definite points within the Woods Hole Region, two of them, indeed, being described from specimens obtained locally. One determined species (*Leptocuma minor*) was taken during the Survey dredging.

The Stomatopoda are represented in our waters by three species, of which only one (the common "Squilla") is at all familiar. None of these species occur, however, in the dredging records.

VIII. DECAPODA.

This group, comprising the largest and most familiar of our Crustacea, is represented locally by 55 species, including four which are listed doubtfully. These are assignable to 20 families and 37(+2?) genera. Of the total number of species listed by us, 27(+2?), or almost exactly one-half, were taken during the survey dredging. Many others were collected by our parties along shore, upon gulfweed, or elsewhere, while a few are recorded wholly on the authority of previous writers. Several of the species (*Portunus ordwayi*, *Arenæus cribrarius*, *Palæmon tenuicornis*, and perhaps *Dissodactylus mellitæ*) had not, so far as we know, been previously listed for the shores of New England.

The published sources of information respecting the occurrence of this group are many. The chief contributors, so far as our New England species are concerned, have been S. I. Smith and M. J. Rathbun.

Smith, in the "Report upon the Invertebrate Animals of Vineyard Sound," listed 36 species of decapods, of which not over a third were definitely recorded for specified points within the region, while at least 5 were extralimital.

In her "List of the Crustacea" ("Fauna of New England" series), Miss Rathbun has included all but four of the decapods comprised in our own list, together with many others which are peculiar to more northern waters.

Whiteaves lists 34 decapods for the waters of eastern Canada, of which 12 are common to the Woods Hole region. The Plymouth catalogue contains 71 representatives of this order, of which only 3 appear to be common to our Woods Hole fauna. Herdman lists 61 decapods for the Irish Sea, while 73 are comprised in Graeffe's catalogue for the Gulf of Trieste.

Most of the decapods collected by us, being of large size and having rather obvious specific distinctions, were listed with full confidence in the field. The others were, for the most part, referred to Miss M. J. Rathbun, to whom we are likewise indebted for criticizing our check-list of local decapods and for information generously given throughout the progress of this work. To Dr. R. P. Bigelow we are indebted for the identification of a number of specimens collected during the first season of the dredging work.

Errors due to the confusion of one species with another in our dredging records are probably negligible in extent, excepting, perhaps, such as may relate to the small crabs of *Panopeus* group (now split into several genera). Upon this point the reader is referred to the statements made under the head of *Eurypanopeus depressus*, *Neopanope texana sayi*, and *Hexapanopeus angustifrons* in the annotated list. It seems possible that specimens identified by the collectors as "*Panopeus sayi*" were in some cases referable to one of the other species. It is probable, however, that the great majority of these crabs actually belong to the species last named, since none of the others are comparable with it in respect to frequency of occurrence. The examination of a large number of our specimens by Miss Rathbun indicates that *Eurypanopeus depressus* is at present comparatively rare in these waters, being by no means the common species which one would infer it to be from the statements of Smith.

The average number of species of decapods recorded by us from the 458 regular stations of the Survey is 3.5 per dredge haul. By far the most prevalent single species was *Pagurus longicarpus*, which was recorded from 290, or over 60 per cent, of the stations. Those species which were dredged at one-fourth or more of the total number of stations (arranged in order of frequency) are:

	Number of stations.
Pagurus longicarpus	290
Cancer irroratus	209
Pagurus annulipes	196
Libinia emarginata	192
Crago septemspinosus	169
Neopanope texana sayi	143

For the various groups of dredging stations and for the various types of bottom the averages are surprisingly uniform. The following figures are taken from the tables on pages 78 and 79:

Vineyard Sound:	
Fish Hawk	3.8
Phalarope	3.2
Buzzards Bay:	
Fish Hawk	3.4
Phalarope	3.2
Type of bottom:	
Sand	3.5
Stones and gravel	3.5
Mud	3.6

The lists of "prevalent" species for these different groups of stations are likewise surprisingly uniform in respect to the species comprised. Of the 6 species listed for one-fourth or more of the total number of stations, 3 appear in all seven of the lists of "prevalent" species; 2 others appear in all but one of these lists, while the remaining species appears in five of the seven lists. The lists of "prevalent" species for the three types of bottom comprise 5 species each. Of these, 4 are common to all three lists.

Of the 13 species for which distribution charts have been presented, 8 are of more or less general occurrence throughout the Sound and the Bay, so that their distribution bears little apparent relation to the character of the bottom. For this reason no such sharp division between Bay-dwelling and Sound-dwelling species can be made here, as was possible, for example, with the Annulata. The species whose distribution is most clearly determined by the nature of the bottom is the "lady crab," *Ovalipes ocellatus.* It will be seen from the chart that this crab is for the most part restricted to the western half of Vineyard Sound, where the bottom is known to consist for the most part of clear sand. That this peculiarity in the distribution of *Ovalipes* is related to the character of the bottom is shown by the fact that it was dredged by us several times near the head of Buzzards Bay, i. e., in the warmest waters of the region, while it is a matter of common knowledge that this species frequents sandy bottoms in shallow water.

Other species which appear upon the chart as restricted wholly or chiefly to Vineyard Sound are *Pinnotheres maculatus*, *Cancer borealis*, *Pelia mutica*, and *Pagurus acadianus.* The first of these is commensal in the mussels, *Modiolus modiolus* and *Mytilus edulis* and in the common scallop, *Pecten gibbus.* The distribution is thus dependent upon that of the hosts. The most frequent host, *Modiolus modiolus*, was, however, very scarce in Buzzards Bay, while *Mytilus* was found living only near the lower end. The occurrence of this species in the dredging records is likewise dependent, of course, upon whether or not the mussels from a given station were opened and examined for the crabs. This was probably done more commonly in Vineyard Sound than in Buzzards Bay. *Pinnotheres* has been taken by us at two supplementary stations in the Bay, on one occasion in *Pecten*, on the other in *Modiolus.*

Cancer borealis was recorded from only one regular station in the Bay,[a] and its occurrence there is certainly infrequent. It is most common at the western end of Vineyard Sound, though taken sparingly throughout its length. The absence of this species from the Bay is probably due in part, at least, to the temperature factor.

Pelia mutica is much less common in the Bay than in the Sound, and its occurrence in the former is restricted mainly to the inshore stations. The distribution of this species displays certain other peculiarities which will be discussed under the head of temperature.

Pagurus acadianus was not recorded once from the Bay, nor indeed was it recorded from the eastern half of Vineyard Sound. Here, too, temperature rather than bottom seems to be the determining factor.

As is well known, the distribution of many of the littoral species of decapods is conditioned by the character of the shore. Certain forms (e. g., the fiddler crabs) are chiefly confined to muddy situations; others (*Palæmonetes vulgaris* and *Hippolyte zostericola*) are found mainly in the beds of eel grass, while the common "*Hippa*" burrows in the sand at low-tide mark, etc. It is therefore rather surprising to find how few of the deeper water species are distributed in accordance with the character of the bottom.

Much more striking, on the other hand, are the examples of distribution in accordance with temperature. While many of our species display no restriction whatever in relation to this factor, certain others are pretty definitely limited to the colder waters of the region, while others still appear to avoid these colder waters, although elsewhere

[a] Later at two supplementary stations near the lower end.

of general distribution. These types will be considered separately. The ranges here stated have been furnished by Miss Rathbun.

Species found predominantly in the colder waters.

Pagurus acadianus	From the Grand Bank of Newfoundland to the mouth of Chesapeake Bay.
Cancer borealis	Nova Scotia to deep water off South Carolina.

Considering the range in latitude alone, it is questionable whether we may fairly assign either of these species to the "northern" group. In both cases, however, it is possible that their occurrence in southern waters is restricted to considerable depths.

Two other species (not plotted) which were taken by us only at the open ends of Vineyard Sound and Buzzards Bay and at Crab Ledge are *Hyas coarctatus* and *Pandalus leptocerus*. These may, perhaps, be regarded as predominantly northern species, though they are recorded (depth not stated) for points far to the southward on our coast.

Species which seem to avoid the colder waters, though elsewhere of general occurrence.

Pagurus annulipes	Nantucket Sound to Indian River, Fla.
Pelia mutica	Vineyard Sound to West Florida.
Neopanope texana sayi	Provincetown to East Florida.

Another species, *Pagurus pollicaris*, might perhaps be added to this list. This hermit crab, it will be seen, was not recorded from the stations at the extreme western end of Vineyard Sound, though elsewhere prevalent. The case is not so striking, however, as those mentioned previously. The range of this latter species is said to extend from Cape Cod Bay to South Carolina.

None of these four species are recorded by us from Crab Ledge. All show, or appear to show, an avoidance of the coldest waters of Vineyard Sound, and all are predominantly southern in their distribution upon our coast. It seems quite likely, therefore, that temperature has been the factor responsible for the peculiarities in their local distribution.

Mention may appropriately be made here of certain species from southern waters which do not properly belong to our local fauna at all. Among these are four crabs (*Planes minutus*, *Portunus sayi*, *Portunus ordwayi*, and *Arenæus cribrarius*) and two shrimps (*Penæus brasiliensis* and *Latreutes ensiferus*). In nearly all cases these species have been found upon the floating gulfweed (*Sargassum bacciferum*), which is the home of so many waifs from the far south.

On the other hand, several shrimps of the genus *Spirontocaris*, which are known to be representatives of a northern fauna, have only been taken from the outlying colder waters of the region.

Very few species among those dredged by us showed any evident restrictions as to depth. This statement does not hold, however, for *Ovalipes ocellatus*, *Cancer borealis*, and *Pagurus acadianus*. All of these were dredged most frequently at depths of 10 fathoms or more, despite the comparatively small number of dredging stations at which such depths were recorded. *Ovalipes*, as we have seen, is by no means to be regarded as a deep-water crab, since it is known to be common on sand flats in shallow water. The greater average depth of the stations from which it was recorded results from its

prevalence in the middle of the Sound near the western end. The bottom here is largely of clean sand and many typical sand-dwelling species, such as *Echinarachnius parma* and various flounders, consequently flourish in this area. *Cancer borealis* and *Pagurus acadianus*, on the other hand, are probably limited to the deeper waters on account of the lower temperatures prevalent there. The latter species was taken only four times by the *Phalarope*, though dredged at 41 of the *Fish Hawk* stations in Vineyard Sound.

Among our local decapods we find a number of cases where interesting differences of habitat are displayed by the various species within a genus. Only a few such may be mentioned here. The differences in habitat shown by the two local members of the genus *Cancer* have already been referred to. These differences seem to relate to temperature, depth (if this is really an independent factor), and perhaps to character of bottom. One *Libinia* (*L. emarginata*) is of almost universal occurrence throughout both the Bay and the Sound; the other (*L. dubia*) appears to be restricted to shallow, inclosed waters. Although it is known to be abundant at some of these points, we do not have a single authentic record of its occurrence in the dredgings.[a] The difference displayed by the various local representatives of the genus *Pagurus* have likewise been discussed in another connection. The almost complementary character of the distribution patterns for *P. acadianus* and *P. annulipes* is especially to be noted.

The following decapods were taken with the dredge during the operations of the Survey. The asterisk, as usual, denotes species which were recorded from 10 or more dredging stations. For all of these, charts have been plotted.

Pandalus montagui.
Pandalus leptocerus.
Hippolyte zostericola.
Spirontocaris grœnlandica.
Spirontocaris pusiola.
*Crago septemspinosus (chart 107).
*Homarus americanus (chart 108).
Callianassa stimpsoni.
*Pagurus pollicaris (chart 109).
*Pagurus acadianus (chart 110).
*Pagurus longicarpus (chart 111).
Pagurus kroyeri.
*Pagurus annulipes (chart 112).
Heterocrypta granulata.
Hyas coarctatus.
*Pelia mutica (chart 113).
*Libinia emarginata (chart 114).
?Libinia dubia (very young).
*Cancer irroratus (chart 115).
*Cancer borealis (chart 116).
?Callinectes sapidus (fragment).
*Ovalipes ocellatus (chart 117).
Panopeus herbstii.
*Neopanope texana sayi (chart 118).
Hexapanopeus angustifrons.
*Pinnotheres maculatus (chart 119).
Pinnixa chætopterana.
Pinnixa sayana.
Dissodactylus mellitæ.

Grouping, as usual, the more prevalent species according to the extent of their known range upon our coast,[b] we have—

Predominantly northern forms.

Homarus americanus..........	Labrador to New Jersey.
Pagurus acadianus............	Grand Bank of Newfoundland to the mouth of Chesapeake Bay. (Northern?).

[a] A few small specimens were thus identified at first, but further quite extensive collecting has thrown doubt upon these determinations.

[b] We are indebted to Miss Rathbun for these statements as to range.

Predominantly southern forms.

Pagurus pollicaris	Cape Cod Bay to South Carolina.
Pagurus longicarpus	Cape Ann, Mass., to Texas.
Pagurus annulipes	Nantucket Sound to Florida.
Pelia mutica	Vineyard Sound to West Florida.
Libinia emarginata	Casco Bay to West Florida.
Ovalipes ocellatus	Provincetown to the Gulf of Mexico.
Neopanope texana sayi	Provincetown to East Florida.
Pinnotheres maculatus	Cape Cod to Texas.

Of approximately equal range north and south.

Crago septemspinosus	East Florida; Arctic Alaska.
Cancer irroratus	Labrador to South Carolina.
Cancer borealis	From Nova Scotia to deep water off South Carolina.

Thus, as in the case of the Annulata and indeed of the majority of other groups, the commoner local Decapoda are predominantly southward ranging species, while only two of them are to be regarded as predominantly northern. Of these two, indeed, one is only doubtfully so classified, while both of them occur far to the southward of the Woods Hole region. The inclusion of various stragglers, both from the north and south, would, of course, increase both lists, but much the same proportions would probably be maintained.

IX. XIPHOSURA.

This order has been established to include the genus *Limulus*, a group of organisms having both crustacean and arachnidan affinities. *Limulus polyphemus*, our only American species, was very seldom taken during the survey dredgings, being primarily a shallow-water animal. With respect to its distribution, it is predominantly a southward-ranging form, occurring, according to Verrill, from Casco Bay to Florida. It has not been recorded for Canadian waters.

X. PYCNOGONIDA.

Of the sea spiders only 6 species appear in our catalogue, and of these 6 one is perhaps extralimital. Our knowledge of the New England species is due in large measure to the labors of E. B. Wilson, supplemented recently by the studies of L. J. Cole.

Only two of the species (*Tanystylum orbiculare* and *Anoplodactylus lentus*) appear with any frequency in the dredging records. The local distributions of these two species, so far as these are shown by our dredgings, are represented in charts 120 and 121. Both species are seen to be confined almost exclusively to Vineyard Sound, and both (particularly *Anoplodactylus*) appear to be restricted to the eastern half of the Sound. One might reasonably expect to find a more exact correlation between the distribution of these species and the distribution of the hydroids among which they live. But little correlation is to be observed, so far as our charts go.

The smaller and less conspicuous of these two pycnogonids (*Tanystylum orbiculare*) was probably frequently overlooked in listing the contents of the dredge, and it is likely, therefore, that this species is of more frequent occurrence than appears from our records. Its distribution, likewise, may be somewhat more general.

This class is represented in our list by a smaller number of species than have been recorded for any of the other stations considered in our comparative table.[a] To what

[a] Except Trieste, where apparently no record has been kept of the Pycnogonida.

degree this is due to the small number actually present in our local waters and to what degree it is due to an insufficient search can not be stated.

The ranges of our two commoner species, as stated by Wilson, are:

Tanystylum orbiculare.........From off Marthas Vineyard to Virginia.
Anoplodactylus lentus.........Long Island Sound; Woods Hole; Eastport, Me. (1 record).[a]

Thus the former appears to be a predominantly southern form, while for the latter the data are insufficient to warrant us in assigning to it a range.

One pycnogonid, which was taken upon the gulfweed on a number of occasions, is *Endeis spinosus* Montagu. This, like the gulfweed fauna in general, is doubtless an exotic species which comes to us from southern waters. Its presence on the weed is rather unexpected, considering the ordinary habitat of this species in European waters.

XI. INSECTA AND ARACHNIDA.

There are, of course, very few strictly marine insects in existence, and it is doubtful whether any of our local species can be so regarded. The thysanuran species *Anurida maritima* is, however, perhaps as nearly marine as are certain of our littoral Crustacea. Verrill and Smith record having taken in the vicinity of Woods Hole a number of insect larvæ, which appear to have been living in sea water. One of these was described by Packard as a new species. Most of the insects listed in that report were, however, beach-dwelling species, which seldom or never enter the water.

The list prepared by the writers comprises for the greater part species taken in brackish ponds in the neighborhood. Many of these were larvæ, and about half of them have not been determined specifically. In many, if not most, cases these insects are ones which are known to dwell in fresh-water ponds as well as brackish ones. It has been thought worth while to include them here, however, since no list has ever been published of our local brackish-water insects.

The single arachnid here listed (*Chernes oblongus*) is scarcely to be regarded as marine, though it has been taken under stones along shore, near low-water mark.

9. MOLLUSCA.

Mollusks, or their shells, have commonly constituted by far the most conspicuous feature of the organic contents of the dredge. In respect to the number of species likewise, the mollusks have generally preponderated, there frequently being more representatives of this group contained in a given dredge haul than of all the other phyla combined. Likewise the total number of molluscan species recorded in the course of our dredging operations is considerably greater than that of even the Crustacea, though the latter group preponderates as regards the number recorded for the region as a whole. It must be stated, however, that the vast majority of specimens taken were merely dead shells, and that many species were rarely or never taken in a living condition. This preponderance of molluscan remains in our dredging records is obviously due to the enduring character of the exoskeleton of these animals, which insures the accumulation of shells, even in the case of the less common species. Another fact which results directly from the one just mentioned is the relatively great frequency with which most of the molluscan species were dredged. Of the 127 species which appear in our dredging records, 68, or more than half, are recorded from more than 10 stations each, while

[a] This is to be regarded as a doubtful record.

23 of these mollusks appear in the list of species which were taken at one-fourth or more of the total number of stations. Thus exactly one-half of the latter list is constituted by Mollusca.

We regard our molluscan records as being, on the whole, relatively complete and comparatively free from error. The species are for the most part large and easy of identification. Fortunately for the collectors, systematic conchology is based largely upon shell characters, so that the determinations could commonly be made with a high degree of confidence in the field. The few cases among the larger species in which confusion was believed to be possible were early recognized, and we believe that errors respecting such forms were nearly always avoided except at the beginning of the work. Wherever doubt was felt, and especially in the case of the smaller species, specimens were preserved for identification by specialists. We were fortunate enough to have the assistance of such well-known authorities as Dr. W. H. Dall and Dr. Paul Bartsch in the identification of the less familiar species of shell-bearing mollusks. We are likewise indebted to Dr. Dall for the critical examination of our manuscript check list and for supplying us with the ranges of distribution which are given below. The classification and terminology adopted are his.[a] The nudibranch mollusks, on the other hand, including many specimens taken in the townet, as well as those which were dredged, were identified by Dr. F. M. MacFarland, of Stanford University, and Dr. MacFarland has likewise kindly revised that portion of the manuscript devoted to this group.

Certain sources of error have, notwithstanding, to be considered in the records for the Mollusca. Some of the minute forms representing the genera *Turbonilla*, *Odostomia*, *Cæcum*, *Cylichna*, etc., were doubtless frequently overlooked, as likewise such small species as *Astyris lunata*, *Lacuna puteola*, *Triforis nigrocinctus*, and *Bittium nigrum*. During the first season's work, especially when less thorough methods of sifting the bottom deposits were employed, it is likely that the records for these forms were much less complete than they were later. Again, the failure to use a canvas mud bag and the consequent escape of the finer components of the bottom material doubtless resulted in many cases in the loss of these small mollusks.

As already mentioned, it was found that during the rather experimental earlier work of the Survey certain forms having a close superficial resemblance had been confused with one another. Since it is believed that these ambiguities have in most cases been eliminated by special dredgings at the points in question, they can not seriously affect the value of our results. Some of the smaller species of *Natica* (*Polynices*) were, it is believed, wrongly identified in the field, and in such cases these records have been entered merely as "*Polynices* sp." Even *Polynices triseriata* was not during the first season always listed separately from *Polynices heros*, of which species it has often been regarded as a variety or even as an immature stage. In consequence of this the records for *P. heros* are doubtless somewhat fuller than they should be, those for *P. triseriata* being correspondingly curtailed.

In a few cases, notably with the small shells of the genus *Turbonilla*, confusion was brought about by our failure to recognize the presence of several species among the specimens taken. Instead of preserving samples of *Turbonilla* shells from every station at which they were encountered it frequently happened that the collectors chose speci-

[a] Except that we have retained the Amphineura in a separate class. Dr. Dall has recently expressed the belief that they constitute "at most an order."

mens from one of the dredge hauls, believing these all to be of one species and therefore regarding them as representative of the specimens taken from various other dredge hauls. Since an examination by Dr. Bartsch revealed the presence at times of three or four species of *Turbonilla* from a single dredging station, it is obvious that such records as are not based directly upon preserved material taken at one station are worthless so far as specific names go. It has been necessary, therefore, to record a large proportion of our Turbonillas merely as "*Turbonilla* sp.;" and thus our data for this interesting genus are in a large degree rendered valueless.

There are some other possible sources of error in interpreting our records which have no relation to defects of method. For example, for certain of the gastropods the apparent distribution is doubtless much more extensive than the actual one, owing to the transportation of their shells by hermit crabs. This is notably true of the introduced periwinkle, *Littorina litorea*, which is typically and indeed almost exclusively a littoral (intertidal) species. Nevertheless the shells of this mollusk were found at 131 stations, occurring even at depths of 10 or 15 fathoms. Other gastropods whose shells are most commonly occupied by the paguri are *Tritia trivittata*, *Anachis avara*, *Ilyanassa obsoleta*, *Polynices heros*, *P. triseriata*, *P. duplicata*, *Busycon canaliculatum*, *B. carica*, *Urosalpinx cinereus*, and *Eupleura caudata*. To what extent the distribution of these species, as plotted in the charts, has been the result of transportation by hermit crabs is impossible to state. It is not recorded in all instances whether or not a given shell was inhabited by one of the crabs, and in any case the presence of the latter in a shell would not by any means prove that this had been carried to any great distance beyond the point where the mollusk lived.

In the case of certain thin shells of light weight it is quite probable that the tidal currents have often been instrumental in carrying them beyond the original habitat of the animal, though we can not, of course, assume this in any single case. Man, likewise, has almost certainly been responsible for the occurrence of the shells of one species, at least, in unexpected localities. The large oyster shells which have been taken not infrequently in various parts of the main channel of Vineyard Sound have probably been cast overboard from passing vessels, since living oysters of our American species are not known to occur in such situations.

In the charts for the Mollusca, as for other shell-bearing organisms, we have indicated the known presence of living specimens at a given station by means of a circle surrounding the star. It must not be inferred, however, that only dead specimens were taken at the other stations. Absence of the circle denotes either that the occurrence of shells only was specified or merely that living specimens were not recorded.[a] It is quite certain that living mollusks were of much more frequent occurrence in our dredge hauls than the circles upon the distribution charts would imply. This is probably particularly true of the small gastropods. Indeed, the chiton *Chætopleura apiculata*, which was seldom taken except alive, was not commonly designated as living or dead in the dredging records. For this reason, it has been necessary to omit the circles from the chart.

For the remainder of this discussion it will be best to consider the classes of Mollusca separately.

[a] For certain mollusks we have employed the circle whenever the nature of the record rendered it probable that living specimens were taken, even though this was not expressly stated. For example, the note "on [or in] hermit crab shells," when applied to *Crepidula*, has been regarded as equivalent to a record of living specimens.

I. PELECYPODA.

Of the bivalve mollusks 70 (+6?) species have been recorded belonging to 31 families and 48(+1?) genera. Of these, 57 species were taken during the Survey dredging and 6 of them were new to the region when first collected by us. So far as known no species new to science have been found.

Verrill and Smith in 1873 listed 84 species of lamellibranchs, of which, however, only 61 were recorded for specified points within the Woods Hole region, although the stated ranges of 12 others would render their occurrence here probable.

In subsequent papers Verrill added greatly to our knowledge of the north Atlantic Mollusca, but most of these later papers dealt chiefly with collections made in much deeper waters.

Before Verrill, Gould (1841, 1870) had catalogued the Mollusca of this state in his well-known "Report on the Invertebrata of Massachusetts." There were here included a large proportion of our Woods Hole species, though comparatively few definite records are offered by Gould relating to the occurrence of mollusks within our region.

It is worthy of note that, although our list of local Pelecypoda is probably fairly complete, it is considerably exceeded by that comprised in each of the other faunal catalogues which have been summarized in our comparative table. Thus the Canadian list contains 100 species, the list for Plymouth 86, that for the Irish Sea 108(+3?), and that for the Gulf of Trieste 107. Thus, even in those cases where the areas comprised are roughly comparable, the other regions exceed our own in the wealth of species. Of the 100 Canadian species 55 (=55 per cent of Canadian list, or about 75 per cent of our own) are common to the Woods Hole region. On the other hand only 5 of the 86 Plymouth species are known to be common to our own fauna.[a]

On an average 9.2 species of bivalve mollusks were taken per dredge haul at all of the 458 regular stations of the Survey. This figure is considerably larger than that representing any other class of organisms. The single species which was taken most frequently was *Arca transversa*, which was recorded from 264 of the stations. The following is a complete list of those species which were taken at one-fourth or more of our dredging stations, the species being arranged in order of frequency:

	Number of stations.
Arca transversa	264
Anomia simplex	256
Ensis directus	235
Clidiophora gouldiana	234
Spisula solidissima	222
Cardium pinnulatum	219
Mytilus edulis	217
Nucula proxima	205
Tellina tenera	193
Callocardia morrhuana	192
Crassinella mactracea	182
Pecten gibbus borealis	162
Corbula contracta	128
Modiolus modiolus	120

[a] As already pointed out, a careful study of synonymy might result in somewhat increasing this number.

A study of the distribution charts shows us that, whereas a considerable number of our local lamellibranchs are of very general distribution throughout Vineyard Sound and Buzzards Bay, a yet greater number show definite restrictions in relation either to the character of the bottom or to temperature. The part played by the bottom in determining the wealth of lamellibranch life is indicated to some extent in the figures representing the average number of species per dredge haul taken upon the three chief types of bottom. These are: Gravel and stones, 7.7; sand, 9.8; mud, 11.0.

These figures are quite in accord with those giving the average number of species per dredge haul in the Sound and the Bay:

Vineyard Sound:	
Fish Hawk	8.2
Phalarope	7.5
Buzzards Bay:	
Fish Hawk	11.5
Phalarope	11.6

It is not evident, however, why the *Phalarope* stations of the Bay, which, on the whole were decidedly less muddy than the *Fish Hawk* stations, should none the less show a larger number of species.

The lists of "prevalent" species for the three types of bottom (i. e., those present at one-fourth or more of the stations) display a degree of uniformity which was unexpected in view of the above shown differences in the wealth of species per dredge haul. The number of prevalent species (16) is the same for sandy as for muddy bottoms, while 13 such species are listed for bottoms of gravel and stones. Of these, 9 are common to the three lists.

Passing to a consideration of the charts (122–160) we find a considerable variety among the distribution patterns, but it seems possible to reduce these to comparatively few types. These last are not, however, to be distinguished sharply from one another.

Of general distribution.

Anomia simplex.
Pecten gibbus borealis (scarce, however, in center of Bay).
Arca transversa.
Nucula proxima.
Cardium pinnulatum.
Callocardia morrhuana.
Tellina tenera.
Ensis directus.
Clidiophora gouldiana.

General in the Sound; common in the Bay, but restricted to inshore stations.

Crassinella mactracea.
Divaricella quadrisulcata (only 20 stations altogether).
Cumingia tellinoides (not exactly general in Sound, and some records for middle of Bay).
Spisula solidissima (some records for middle of Bay).
Cochlodesma leanum.
Corbula contracta.

General in the Sound; in the Bay, restricted to lower half.

Mytilus edulis.
Astarte castanea.
Petricola pholadiformis.

Restricted wholly or chiefly to the Sound.

Anomia aculeata.
Pecten magellanicus.
Modiolus modiolus (a few inshore stations in Bay).
Crenella glandula.
Arca ponderosa.
Venericardia borealis.
Thracia conradi.

Restricted wholly or chiefly to the Bay.

Arca pexata.
Yoldia limatula.
Solemya velum (confined to inshore stations).
Lævicardium mortoni (most abundant at inshore stations).
Venus mercenaria.
Tagelus gibbus (confined to inshore stations).
Macoma tenta.
Mulinia lateralis.
Mya arenaria (confined to inshore stations).

It will be noted that even some of those species which are restricted to Buzzards Bay (*Solemya velum, Tagelus gibbus, Mya arenaria*) are found there only at the inshore stations. Another species which is, on the whole, restricted to these stations, both in the Bay and the Sound, is *Lyonsia hyalina.*

An analysis of our records shows that certain species appear to exhibit marked preferences as to the depth of the water which they occupy. The following, for example, are in considerable degree restricted to depths of 5 fathoms or less:

Pecten gibbus.
Arca pexata.
Solemya velum.
Tagelus gibbus.
Lyonsia hyalina.
Mya arenaria.

Four of these six species are those which have just been mentioned as restricted to the inshore stations.

Species which were dredged most frequently at depths of 10 fathoms or more[a] are:

Pecten magellanicus.
Modiolus modiolus.
Modiolaria nigra.
Crenella glandula.
Venericardia borealis.
Astarte undata.
Astarte castanea.
Cyclas islandica.
Thracia conradi.

With the exception of the two species of *Astarte*, all of those comprised in this last list will be found in the list of predominantly northern species given below. And, with the exception of *Astarte castanea* and *Modiolus modiolus*, all are more or less restricted to the colder portions of the Sound and the Bay.[b] Reference to the charts shows that the remaining seven species occur wholly or predominantly in the western half of Vineyard Sound and the lower end of Buzzards Bay. Five of these species (*Pecten magellanicus, Crenella glandula, Venericardia borealis, Astarte undata*, and *Cyclas islandica*) were likewise taken at Crab Ledge, where, as we have seen, many of our typical colder water

[a] Depths of 10 fathoms or more were recorded at only 36 per cent of the 458 stations. All these species were, nevertheless, dredged an absolutely greater number of times at such depths.

[b] As stated above (p. 28), the western half of Vineyard Sound is little if any deeper than the eastern half. The greater average depth at which these species occurred results from the fact that they were rarely taken near shore. Thus they figure but little in the *Phalarope* dredgings.

species are to be found. And six of them are comprised in the list of predominantly northern species given below.

Interesting comparisons between the distributions of different members of the same genus may be made for the genera *Anomia*, *Arca*, *Astarte*, and *Pecten*. The case of the two local species of *Astarte* is peculiar inasmuch as there is nothing in their ranges, so far as we know, which gives a clue to the differences which they display in their local distribution.

Certain species among the lamellibranchs dredged by us have never been taken in a living condition. Of these the most striking examples are *Arca ponderosa* and *Thracia conradi*. The former, indeed, has never been recorded living, so far as we know, north of Cape Hatteras, although fairly fresh shells have sometimes been found. It seems likely that both of these species may bury themselves too deeply in the bottom to be taken by the dredge.

Those species which were taken at 10 or more dredging stations have, as usual, been grouped, so far as possible, into predominantly northern and predominantly southern forms. The ranges given for the Pelecypoda and for the mollusks in general are those stated by Dall.[a]

Predominantly northern (13).

Anomia aculeata (chart 124)....Arctic Ocean to Cape Fear.
Pecten magellanicus (chart 125).Labrador to Cape Hatteras.
Mytilus edulis (chart 127)......Arctic Sea to North Carolina.
Modiolus modiolus (chart 128)..Arctic Sea to North Carolina (Florida?).
Modiolaria nigra (chart 129).....Arctic Sea to Cape Hatteras.
Crenella glandula (chart 130)...Arctic Sea to Cape Hatteras.
Nucula proxima (var. trunculus Dall) (chart 134).............Nova Scotia to New York.
Yoldia limatula (chart 135).....Arctic Ocean to North Carolina.
Venericardia borealis (chart 137) Hudson Strait to off Hatteras.
Cardium pinnulatum (chart 142) Labrador to Cape Lookout.
Cyclas islandica (chart 144)....Arctic Ocean to Cape Hatteras (at latter point in deep water only).
Spisula solidissima (chart 153)..Labrador to Cape Hatteras.
Thracia conradi (chart 155).....Labrador to Cape Hatteras.

Predominantly southern (19).

Ostrea virginica (chart 122)....Prince Edward Island to West Indies.
Anomia simplex (chart 123)....Cape Sable to Martinique.
Pecten gibbus borealis (chart 126)........................Nova Scotia to Tampa, Fla.
Arca ponderosa (chart 131).....Provincetown to Yucatan.
Arca transversa (chart 132).....Cape Cod to Mexico.
Arca campechiensis pexata (chart 133)..................Cape Cod to Texas.
Crassinella mactracea (chart 140)........................Cape Cod to Florida.
Divaricella quadrisulcata (chart 141)........................Cape Hatteras to Brazil. (Woods Hole region.)
Lævicardium mortoni (chart 143) Nova Scotia to Venezuela.
Venus mercenaria (chart 145)...Nova Scotia to Yucatan.

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[a] Dr. Dall has kindly furnished us with some unpublished notes, which modify to some degree the ranges as stated in his "Preliminary Catalogue of the Shell-bearing Marine Mollusks."

Callocardia morrhuana (chart 146)......................Prince Edward Island to Florida.
Petricola pholadiformis (chart 147)......................Prince Edward Island to Nicaragua.
Tagelus gibbus (chart 148)......Cape Cod to Brazil.
Tellina tenera (chart 149)......Prince Edward Island to Barbados.
Macoma tenta (chart 150).....Cape Cod to Haiti.
Cumingia tellinoides (chart 152) Cape Cod to south Florida.
Mulinia lateralis (chart 154)....New Brunswick to Texas.
Lyonsia hyalina (chart 157)....Nova Scotia to Texas.
Corbula contracta (chart 159)...Cape Cod to Jamaica.

Of approximately equal range north and south (7).

Solemya velum (chart 136).....Nova Scotia to North Carolina.
Astarte undata (chart 138)......Gulf of St. Lawrence to Cape Hatteras.
Astarte castanea (chart 139)....Nova Scotia to New Jersey and off Hatteras (deep).
Ensis directus (chart 151)......Labrador to Texas.
Cochlodesma leanum (chart 156) Nova Scotia to Hatteras.
Clidiophora gouldiana (chart 158)......................Nova Scotia to New Jersey (North Carolina?).
Mya arenaria (chart 160)........Arctic Sea to Miami, Fla.

It will be seen that exactly one-third of these species have been listed as predominantly northern, while very nearly one-half are to be regarded as southern. The seven remaining species are not assignable to either division.

The following species are recorded from our dredgings, but were not taken frequently enough to warrant us in plotting their distributions:

Pecten islandicus.
Modiolus demissus.
Modiolaria lævigata.
Nucula delphinodonta.
Astarte quadrans.
Aligena elevata.
Phacoides filosus.
Cardium ciliatum.
Gemma gemma.
Tellina tenella.
Siliqua costata.
Thracia septentrionalis.
Periploma papyracea.
Saxicava arctica.
Cyrtodaria siliqua.
Pholas costata.
Zirphæa crispata.
Teredo navalis.

Most of these species appear to be actually rare within the region. Several of them, on the contrary (*Modiolus demissus, Gemma gemma, Teredo navalis*) are extremely abundant in their proper habitats, though rarely taken with the dredge.

II. AMPHINEURA.

Of the Amphineura, or chitons, only two species are found in this region. One of these, *Trachydermon ruber*, is quite rare locally. We have met with it but twice in dredging, only a single specimen having been taken on each occasion. Both were found near the lower end of Buzzards Bay. This species is essentially a northern one, being said to range from the Arctic Sea to New York. The other, *Chætopleura apiculata*, is scattered pretty generally throughout the eastern half of Vineyard Sound and along the shores of Buzzards Bay (chart 161). Its scarcity in the western portion of the Sound and its apparent absence from the deeper waters of the Bay are perhaps due chiefly to the character of the bottom. As is well known, the chitons adhere to solid objects, such

as stones and shells.[a] On the other hand, it is not improbable that the temperature factor has been partly responsible for the distribution of *Chætopleura* in Vineyard Sound, as in the case of a number of other southern species which appear to avoid the colder waters of the region. Like those which have previously been discussed, *Chætopleura* was not recorded by us from Crab Ledge. The range of this species, as stated by Dall, extends from Cape Cod to Haiti. Our region thus lies at or near its northernmost limit of distribution.

III. GASTROPODA.

Of the Gastropoda we have recorded 123 determined species, together with 10 which were doubtful or undetermined. Sixty-four (+2?) of these species were encountered during our Survey dredgings, and at least 17 are believed to have been previously unrecorded for the region.

Verrill and Smith, in their Vineyard Sound report, listed 93 species, of which, however, only 65 were definitely recorded for specified points within the region, although the ranges of 20 more, as stated by them, would include the Woods Hole region. The completeness of Verrill's list, as regards our more familiar species, renders conspicuous two exceptions. One is our now abundant periwinkle, *Littorina litorea*, which did not reach Woods Hole in its southward migration until the year 1875; the other is *Lacuna puteola*, an allied species though quite a minute one, which is likewise very common here at the present time. Whether or not this latter mollusk is also a comparatively recent immigrant can not be stated. It has long been known in the British Isles.

In the case of the gastropods, as in that of the lamellibranchs, our list of species is greatly exceeded by all of the other faunal catalogues which have been summarized in our comparative table. The difference in favor of the Plymouth catalogue is due largely, if not wholly, to the inclusion of a greater number of nudibranchs. It is not unlikely that sufficient attention to our local nudibranchs on the part of a specialist would result in adding considerably to the number of species recorded for the region. As regards the shell-bearing species, however, we believe our list to be relatively complete for local waters.

The average number of species of gastropods taken per dredge haul for the 458 regular stations of the Survey was 6.8. This figure is only exceeded by that for the Pelecypoda.

Those species which were so common as to be recorded from one-fourth or more of our dredging stations are listed herewith in the order of frequency:

	Number of stations.
Tritia trivittata	373
Crepidula fornicata	326
Anachis avara	295
Crepidula plana	291
Astyris lunata	245
Polynices heros	165
Urosalpinx cinereus	156
Polynices triseriata	144
Littorina litorea (shells only)	131

[a] Its apparent scarcity, even upon the stony bottoms off the shores of Cuttyhunk and Gay Head, renders the alternative explanation more likelyf or these points.

As in the case of the lamellibranchs, the average number of gastropod species taken per dredge haul was considerably greater for Buzzards Bay than for Vineyard Sound. This statement applies equally to the *Fish Hawk* and the *Phalarope* stations. The average number for dredge hauls upon muddy bottoms (7.8) is likewise seen to exceed that for the other types of bottom, though the difference is much less pronounced than for the bivalve mollusks; while the figure for sandy bottoms (6.5) is seen to be practically the same as that for bottoms of gravel and stones (6.7). The difference, in this respect, between the two chief classes of mollusks is doubtless due to the fact that the Pelecypoda comprise a considerable proportion of burrowing forms.

Reference to the tables giving the "prevalent" species for each type of bottom shows that there are 8 such species recorded for sandy bottoms, 9 for gravelly and stony ones, and 11 for muddy ones. Of these, 7 species (or their shells, at least) are common to the three lists.

Charts 162 to 188 portray the distribution of most of those species which were recorded from 10 or more of our stations in Vineyard Sound and Buzzards Bay. The exceptions are *Natica pusilla*, for which no chart has been presented, owing to the ambiguity of many of the records (see p. 144), and certain species of *Turbonilla*, several of which were doubtless taken with considerable frequency. Owing to a confusion, already referred to, in our original records we have devoted a single chart to all the members of this genus, so far as recorded by us.

In respect to their distribution in local waters, we may group the gastropods in much the same way as has already been done for the pelecypods.

Of general distribution.

Busycon canaliculatum.
Tritia trivittata (commonest recorded species).
Anachis avara.
Urosalpinx cinereus (comparatively few in middle of Bay).
Turbonilla sp. sp.
Crepidula fornicata.
Crepidula plana.
Polynices duplicata.
Polynices triseriata.

General in Sound; in Bay mainly confined to inshore stations.

Astyris lunata.
Cerithiopsis emersonii (hardly general in Sound).
Vermicularia spirata (hardly general in Sound; mostly confined to eastern half).

Restricted mainly or wholly to Sound.

Buccinum undatum.
Crucibulum striatum.
Polynices heros.

Restricted mainly or wholly to Buzzards Bay.

Tornatina canaliculata.
Cylichnella oryza.
Busycon carica.
Ilyanassa obsoleta (mostly in upper half of Bay).
Eupleura caudata (in Sound, mainly near shore).
Bittium alternatum (adlittoral).
Cæcum cooperi (adlittoral).

The last two species (*Bittium alternatum* and *Cæcum cooperi*) were confined almost wholly to the inshore stations of the Bay. Two other species, *Lacuna puteola* and *Crepidula convexa*, while found alike in the Sound and the Bay, are restricted in both largely

to the inshore stations. The case of *Crepidula convexa* is peculiar, inasmuch as the two other local species of *Crepidula* are both of very general distribution. The distribution of this species is particularly unintelligible, in view of the fact that none of our hermit crabs, upon whose shells it finds lodgment, are in any degree restricted to the shallower waters along shore. Yet this mollusk was recorded from 45 of the *Phalarope* and *Blue Wing* stations, as compared with only 16 *Fish Hawk* stations; and of these last, indeed, there is reason for regarding a considerable number as doubtful. This species is known to be the commonest *Crepidula* upon the smaller hermit crabs in shallower waters near shore, but it is difficult to understand why this mollusk is not more frequently carried by its hosts into the deeper waters as well.

As in the case of the Pelecypoda, certain species of gastropods are restricted to the colder waters of the Sound. The only two to be mentioned are *Buccinum undatum* and *Crucibulum striatum*. The former was likewise taken at 6 of the 7 regular stations at Crab Ledge, and is known to be a predominantly northern species. Such is not true of *Crucibulum*, however, and we are at a loss to explain this peculiarity in its local distribution.

Both of these species (and these alone among the gastropods) were taken predominantly at depths of 10 fathoms or more. In fact *Crucibulum* was dredged only once by the *Phalarope*, and was never taken in less than 10 fathoms of water.

Certain species among those charted are seen to be less common, or to be wanting altogether, in the western half of the Sound, although present in the eastern half. Such are *Cerithiopsis emersonii* and *Vermicularia spirata*. Two others (*Eulima conoidea* and *Seila terebralis*) might also be mentioned here, though neither has been taken with sufficient frequency to warrant our drawing any general conclusions.

The distributions of two species of gastropods as portrayed upon our charts are obviously largely fictitious. We refer to *Littorina litorea* and *Ilyanassa obsoleta*, both of which are known to be restricted, when living, to the immediate vicinity of the shore. The broadcast way in which the shells of these species, particularly the former, are strewn around the local sea floor testifies strongly to the part played by hermit crabs in transporting them.

Several genera comprise species which display among themselves interesting differences of habitat. Such are *Busycon*, *Crepidula*, *Littorina*, and *Polynices*. For most of these the differences may readily be seen by reference to the charts. The case of *Crepidula* has just been discussed; that of *Polynices* receives some mention in chapter V (p. 186). As regards *Littorina*, only one species is represented upon our chart, and this latter in no way represents the distribution of the living animals. In the catalogue of species (section III), however, the differences in their respective habitats have been briefly indicated.

A glance at the subjoined lists shows that our local assemblage of gastropods, or at least the commonest and most representative among them, are even more dominantly southern than are the pelecypods. Of the 27 species there considered, 22 are to be regarded as southern, 3 as northern, while the remaining 2 are not to be assigned to either category.

Predominantly northern (3).

Buccinum undatum (chart 166)....Arctic Sea to Charleston Harbor.
Polynices heros (chart 187).......Labrador to Virginia.
Polynices triseriata (chart 188).....Labrador to off Hatteras.

Predominantly southern (22).

Tornatina canaliculata (chart 162)..Portland, Me., to Haiti.
Cylichnella oryza (chart 163)......Cape Cod to Charleston, S. C.
Busycon canaliculatum (chart 164)..Beverly, Mass., to Gulf of Mexico.
Busycon carica (chart 165).........Cape Cod to St. Thomas, West Indies.
Tritia trivittata (chart 167)........Nova Scotia to St. Augustine, Fla.
Ilyanassa obsoleta (chart 168)......Nova Scotia to Tampa, Fla.
Anachis avara (chart 169)..........Casco Bay to Florida Keys.
Astyris lunata (chart 170)..........Cape Ann to Brazil.
Eupleura caudata (chart 171).......Cape Cod to West Indies.
Urosalpinx cinereus (chart 172)....Prince Edward Island to St. Augustine, Fla.
Eulima conoidea (chart 173).......Hatteras to West Indies. (Woods Hole region.)
Seila terebralis (chart 175).........Massachusetts Bay to Haiti.
Cerithiopsis emersonii (chart 176)...Cape Cod to Grenada, West Indies.
Bittium alternatum (chart 177).....Prince Edward Island to Louisiana.
Cæcum cooperi (chart 178) ....Cape Cod to Jamaica.
Vermicularia spirata (chart 179)....New England to Bahia, Brazil.
Crucibulum striatum (chart 182)...Nova Scotia to Florida Keys.
Crepidula fornicata (chart 183).....Prince Edward Island to New Granada.
Crepidula convexa (chart 184).....Nova Scotia to Florida; (Texas?).
Crepidula plana (chart 185)........Prince Edward Island to Bahia, Brazil.
Natica pusilla....................Eastport, Me., to Florida.
Polynices duplicata (chart 186)....Massachusetts Bay to Mexico.

Of approximately equal range, north and south.

Littorina litorea (chart 180)........Nova Scotia to Cape May, N. J.

Of doubtful position.

Lacuna puteola (chart 181)........Woods Hole region; Stonington, Conn.; England.

The following is a list of species which were recorded with relative infrequency (at less than 10 stations) during the dredging:

Cylichna alba.
Haminea solitaria.
Cratena pilata.
Coryphella mananensis.
Coryphella salmonacea.
Doto coronata.
Mangilia cerina.
Drillia sp.
Chrysodomus decemcostatus.
Tritonofusus islandicus.
Tritonofusus stimpsoni.
Arcularia vibex.
Thais lapillus.
Boreoscala grœnlandica.
Epitonium multistriatum.
Epitonium dallianum.
Epitonium lineatum.
Stilifer stimpsoni.
Turbonilla nivea.
Turbonilla vineæ.
Turbonilla elegantula.
Turbonilla areolata.
Turbonilla interrupta.
Turbonilla winkleyi (this and probably several others were taken at more than 10 stations).
Turbonilla rathbuni.
Odostomia seminuda.
Odostomia trifida.
Triforis nigrocinctus.
Cæcum pulchellum.
Littorina rudis.
Lacuna vincta.
Rissoa arenaria.
Cingula minuta.
Polynices immaculata.
Velutina lævigata.
Velutina zonata.
Acmæa testudinalis.
Margarites obscurus.

Some of these species (*Thais lapillus*, *Littorina rudis*, *Lacuna vincta*, *Acmæa testudinalis*) are more or less common along shore, but rarely find their way into the dredge. A considerable number of the species were, on the other hand, only taken at Crab Ledge, and thus do not form any part of the fauna of Vineyard Sound or Buzzards Bay.

The group of pelagic gastropods known as the Pteropoda is represented locally by a few species which are occasionally found in the outlying waters of the region. Only one of these, *Cavolina tridentata*, has been met with in the dredge, a single shell having been taken near the western end of Vineyard Sound. Such a state of affairs is in striking contrast to the condition in some parts of the Atlantic Ocean, where the remains of this class of mollusks accumulate to such a degree as to form a veritable "pteropod ooze," covering wide tracts of the sea floor.

IV. CEPHALOPODA.

Two species of squid, *Loligo pealii* and *Ommastrephes illecebrosus*, are found in these waters. Only the former of these has been met with in dredging. *Loligo* has been frequently taken in the *Fish Hawk* dredgings throughout both the Sound and the Bay, being recorded from 73 stations (chart 189). It has never, however, been dredged by the *Phalarope*. This is doubtless due to the active movements of this animal, which would not be readily caught in a small dredge net, although it would be taken without difficulty by the beam trawl. The eggs of the squid, on the other hand, were brought up very frequently both by the *Fish Hawk* and the *Phalarope*. The range of this species, as stated by Dall, is from Penobscot Bay, Me., to South Carolina. It thus ranks among the predominantly southern species.

Shells of the little known *Spirula peronii* sometimes drift to the outer island shores, and one specimen of an octopus (*Parasira catenulata*) was taken many years ago in Vineyard Sound.

10. ADELOCHORDA.

One species of *Balanoglossus* (*B. aurantiacus* (Girard)) is common at various points along shore, where it burrows rather deeply into the sand or gravel. So far as we know, it has never been taken locally with the dredge.

11. TUNICATA.

Tunicates, particularly the compound forms, constitute a conspicuous feature of the fauna of some portions of our local sea bottom. Certain species likewise abound on piles and on eel grass and rockweed along shore, while one or more pelagic forms are occasionally abundant within the limits of our region. The total number recorded, however, is small, only 22 [a] determined species being included with certainty in our catalogue; together with about 10 which are unidentified or doubtful. Of these 14(+6?) were encountered during our dredging operations. The average number of species taken per dredge haul was only 1.1, though considerable clusters of *Styela partita*, associated with *Molgula manhattensis*, *Perophora viridis*, *Didemnum lutarium*, and perhaps other compound forms were at times brought up together. The form having the most general

[a] Throughout our records *Amaroucium pellucidum* and "*Amaroucium constellatum*" were listed separately and treated as independent species. Owing to the ready distinguishability of these two forms and their somewhat different habitats we have not thought it worth while to readjust our records and computations, despite Dr. Van Name's seeming demonstration of the specific identity of the two.

distribution was *Didemnum lutarium* Van Name, which was taken at 99 of the regular dredging stations; thus not a single species was taken with sufficient frequency to appear in the list of those recorded from one-fourth or more of the entire number of stations. Only eight species were taken at as many as 10 of the stations.

As in the case of some other groups, certain of the earlier identifications by the collectors in the field were made with a confidence which did not afterwards seem to us justified. During the later seasons, accordingly, we preserved for reference to specialists a much larger proportion of the specimens taken. The only instances of ambiguity in our records, which seem worth considering, relate to the species of *Amaroucium* and to *Molgula arenata*. The former were commonly identified in the field by means of a superficial examination. Subsequent information leads us to believe that such identifications were for the most part correct; since the commoner, at least, among our local species are in most cases readily distinguishable by obvious characters. The small, sand-covered solitary ascidians, taken in the western portion of Vineyard Sound, were at first referred by us to a single species, *Molgula arenata*. We were informed by Prof. Ritter, however, that another of our local species, *Eugyra glutinans*, is superficially very similar to the former, and that, in the case of preserved specimens, dissection is necessary in order to distinguish between the two. Both species have been determined by Prof. Ritter in the material submitted to him; so that we feel confident in listing both of them for the western part of Vineyard Sound. On the other hand, it is more than possible that some of our earlier records for "*Molgula arenata*" refer in reality to *Eugyra glutinans*, while some of those for the latter species depend upon an assumed specific identity between specimens which were hastily examined and others which had been authoritatively determined. In view of this uncertainty, it has been thought best to plot but a single chart for these two species, denoting by the stars of solid black those stations from which *Molgula arenata* was recorded, and by the open stars stations from which *Eugyra glutinans* was recorded.

It is thought likely that errors of omission have been relatively infrequent in our records, since few of the local species, so far as known, are minute or inconspicuous. It is not unlikely, however, that some of the smaller sand or mud covered solitary ascidians may have escaped us, and it is possible that certain less common species (e. g., of *Molgula*) have been confused with the more familiar ones and recorded along with the latter.

We are indebted to Prof. W. E. Ritter, of the University of California, for identifying a large number of the simple ascidians, and to Dr. W. G. Van Name, of New Haven, for identifying many of the compound forms. To these same authorities we are likewise indebted for criticizing the manuscript relating to each of these respective subdivisions, and we have adopted the classification and nomenclature advised by them. Prof. Ritter expresses himself as being skeptical regarding the identity of many of the Atlantic coast species, and some of his determinations have been made with no great confidence. In such cases the doubtful character of the identification has been indicated in the list. Dr. Van Name has felt himself justified in making two rather radical changes respecting the genera *Amaroucium* and *Leptoclinum* (*Didemnium*). (See faunal catalogue, p. 731–733).

To Prof. W. A. Herdman, of Liverpool University, we are indebted for suggestions and advice relative to this group during the later stages of the writing of this report.

Verrill and Smith (1873) listed 18 determined species of tunicates for local waters, together with two which were not definitely recorded for the region, and five others which were not specifically determined. A number of these ascidians had been recently described by Verrill himself from specimens taken in the vicinity of Woods Hole. The *Leptoclinum luteolum* of Verrill is not regarded by Dr. Van Name as specifically distinct from the *L. albidum* of the same author, which, contrary to the belief of Verrill, does not appear to occur within the limits of our region. The "*Ciona tenella*" of Stimpson and of Verrill is now regarded as identical with *C. intestinalis* (Linnæus), while the "*Salpa caboti*" of Desor, which appears in Verrill's list, is not believed to be distinct from the *Salpa democratica-mucronata* of Forskäl.[a]

Certain species listed by Verrill (*Molgula papillosa, M. pellucida, M. producta, Eugyra pilularis, Cynthia carnea, Glandula arenicola*) have not been recorded for local waters by any subsequent writers.[b] On the other hand, one species new to science (*Bostrichobranchus molguloides*) was described by Metcalf from specimens taken within recent years in Buzzards Bay. Another species (*Didemnum lutarium* Van Name) although abundant and familiar locally, was only recently described for the first time. This species had hitherto been confused with Verrill's *Leptoclinum albidum* (=*luteolum*), the true home of which is north of Cape Cod. The survey has encountered a number of species which have not previously been listed in any published report of the fauna of this region. Such are *Ascidia complanata, Eugyra glutinans,* and *Salpa zonaria-cordiformis;* also (doubtfully determined) *Molgula koreni, M. citrina,* and *M. pannosa.*

Twenty-eight species of Tunicata are recorded by Whiteaves for eastern Canada; 36 species are comprised in the Plymouth list; 45(+14?) for the Irish Sea; and 75 for the Gulf of Trieste. Ten of the Canadian species and 2 of the Plymouth species appear to be common to our Woods Hole fauna. In considering any such comparisons, however, it must be borne in mind that practically no papers have been published during the past 30 years which deal with the New England Tunicata.

Only eight charts (190–197) have been presented as illustrating the distribution of the bottom-dwelling ascidians of Vineyard Sound and Buzzards Bay. Of these, seven are each for a single species, while another is based upon the records for two species (*Molgula arenata* and *Eugyra glutinans*) concerning which some confusion exists (see p. 156).

Like most of the fixed organisms which have been discussed in the present report, the ascidians are of far less frequent occurrence in Buzzards Bay than in Vineyard Sound. Indeed, only two species, *Molgula manhattensis* and *Didemnum lutarium,* occur with any frequency in the Buzzards Bay dredgings. The following figures permit a comparison of the average number of species per dredge haul taken in the two bodies of water:

Vineyard Sound:	
Fish Hawk	1.3
Phalarope	1.6
Buzzards Bay:	
Fish Hawk	.4
Phalarope	.7

[a] Ritter.

[b] These are all contained in the list of molgulids having "very imperfect descriptions" in Herdman's "Revised Classification of the Tunicata" (Journ. Linnaean Soc., vol. XXIII, 1891, pp. 557–652).

Far in excess of any of these figures is that expressing the number of species taken at the seven Crab Ledge stations. This is 3.3 per dredge haul. Certain localities in Vineyard Sound, likewise, notably the area between the Middle Ground and the shores of Marthas Vineyard were especially rich in tunicates. For example, five species each were taken at stations 63 and 7525, while six species were taken at station 7751.

As in many previous cases which have been discussed by us, we believe that the well-known difference between the bottoms of Buzzards Bay and Vineyard Sound is chiefly responsible for this difference in the wealth of their ascidian faunas. This belief is strengthened by a consideration of the average number of species per dredge haul taken upon the three principal types of bottom which have been distinguished by us. The figures, according to this basis of classification, are as follows: Mud, 0.4; sand, 0.9; stones or gravel, 1.9. Moreover, as in many previous cases, some of the species which are absent elsewhere in the Bay have been taken near shore, where the mud of the central region largely gives place to sand, gravel, and stones. Such in particular are *Styela partita* and *Amaroucium pellucidum constellatum*.

As is well known, ascidians are dependent upon ciliary currents for the food and oxygen brought to them in the water. It is thus natural that bottoms of soft mud should not commonly offer them a congenial habitat, even though a suitable basis for attachment should be present.[a] The occurrence of stones, shells, and algæ, or other suitable bases of support is likewise an important factor in determining the distribution of most species, as is evident from a comparison of the abundance of ascidian life upon bottoms of stones and gravel with that upon bottoms of sand. Herein, also, probably lies the explanation of the scarcity of bottom-dwelling tunicates in the western half of Vineyard Sound.

Of the seven species[b] for which separate distribution charts have been plotted, all agree in being either wholly lacking in the western half of Vineyard Sound, or, if present there at all, in being confined to the inshore (adlittoral) stations. As has been already pointed out, this western area of Vineyard Sound (barring the inshore region) is characterized by the presence of sand, and by the comparative absence of stones and gravel. In the case of *Styela partita*, *Molgula manhattensis*, and *Perophora viridis*, it is possible that distribution is in some measure determined by that of certain algæ, since these species are very frequently attached to the latter. An inspection of the distribution charts for the algæ, however, shows few species, if any, whose distribution would satisfactorily account for that of the ascidians named.

On a number of previous occasions, we have shown the likelihood that temperature has been the factor chiefly concerned in excluding certain species from the western end of Vineyard Sound. Various predominantly southern species seem unable to thrive in the colder waters of the region, just as certain northern forms seem unable to thrive elsewhere. Now an inspection of the table below, giving the ranges of our commoner species of ascidians, shows that none of those listed are predominantly northward ranging forms, while four, on the other hand, are predominantly southward ranging forms, some of which, indeed, reach their northern limit in Cape Cod. Despite these facts, it seems to us unlikely that temperature has been the factor chiefly concerned in determining the

[a] Exception must be made in the case of those species occurring in deep-sea oozes, many of which are stalked. (Herdman).

[b] Two of these are not now regarded by Dr. Van Name as being specifically distinct, but for reasons stated above (p. 155, footnote) their distributions have been plotted separately.

scarcity of ascidians in this portion of Vineyard Sound, since several of the forms in question (*Didemnum* and all of the species of *Amaroucium*) are abundant in this cold water, on the stony bottoms close to shore,[a] and even on Devils Bridge, off Gay Head. On the other hand, *Molgula arenata* (chart 190), likewise a predominantly southward ranging form, as judged from known records, occurs chiefly in the western part of Vineyard Sound, where its congenial habitat, a sandy bottom, is more prevalent.[b]

It would thus seem probable that the temperature factor plays little or no part in determining the distribution of ascidians within the limits of our charts, the primary factor being the character of the bottom, either directly or in its effect upon the distribution of marine algæ.

In the outlying colder waters, however, where northern representatives of nearly every phylum have been met with, we have found a number of ascidians proper to the "Acadian" fauna. Such are *Halocynthia echinata*,[c] *Ascidia complanata*, and the *Boltenia* recorded in the annotated list, all of which species have been dredged by us at Crab Ledge.

An interesting difference of distribution in relation to depth is revealed by an analysis of the records for *Amaroucium pellucidum constellatum* and *A. stellatum*. The latter was dredged only once at a depth less than 5 fathoms, while in more than 60 per cent of the cases it was taken at depths of 10 fathoms or more.[d] *A. constellatum*, on the other hand, was recorded 15 times from depths less than 5 fathoms, while in over 60 per cent of the cases it was taken at depths under 10 fathoms. This form is likewise known to occur upon piles, etc., in shallow water, while we have not observed *A. stellatum* in such situations.

The following list comprises all those species which were recorded in our dredging. The asterisk has the usual significance.

? Molgula citrina.
? Molgula koreni.
* Molgula manhattensis (chart 191).
? Molgula pannosa.
* Molgula arenata (chart 190).
Eugyra glutinans (chart 190).
Halocynthia echinata.
Boltenia sp.
* Styela partita (chart 192).
Styela sp. (Perhaps new.—Ritter).
Ascidia complanata.
Botryllus schlosseri.
* Perophora viridis (chart 193).
* Didemnum lutarium (chart 194).
Aplidium pallidum.[e]
* Amaroucium pelludicum[e] (chart 195).
* Amaroucium pelludicum constellatum[e] (chart 196).
Amaroucium glabrum.[e]
* Amaroucium stellatum[e] (chart 197).
Amaroucium sp. (Perhaps new.—Ritter).

The ranges here stated for the eight commoner species are given for the most part on the authority of Verrill (1873) and of Van Name (1910). The statements of the latter author have been followed for the compound forms, but for the simple ones no data later than those offered by Verrill appear to be available.

[a] It is true that the summer temperature of these shoal inshore waters is somewhat higher than that of the deeper waters in the middle of the channel.

[b] *Eugyra glutinans*, another sand-dwelling species occurring in this same region, is however, a predominantly northern form.

[c] This was likewise taken at Sankaty Head and once in Vineyard Sound.

[d] This notwithstanding the fact that depths as great as this were encountered at only 36 per cent of the stations.

[e] These five species are among those listed by Herdman as "unrecognizable Polyclinidæ." However imperfect the original descriptions may have been, these names none the less refer to well-known and readily distinguishable members of our local fauna.

Predominantly southern.

Molgula manhattensis	Casco Bay to North Carolina.
Styela partita	Massachusetts Bay to North Carolina.
Perophora viridis	Vineyard Sound to Beaufort, N. C., and Bermuda.
A. pellucidum	Vineyard Sound to North Carolina.

Of uncertain position.

Molgula arenata	Long Island Sound to Nantucket.
Didemnum lutarium	New England coast south of Cape Cod.
Amaroucium stellatum	Vineyard Sound to North Carolina (?).
A. pellucidum constellatum	Isles of Shoals (?) and Gloucester to Cold Spring Harbor, Long Island.

Thus, according to the information at our disposal, four of these eight species are to be regarded as predominantly southern, while the remaining four have only been authentically recorded from a very limited section of the coast. Only three species are known to occur north of Cape Cod.

12. PISCES.

The group of fishes occupies a peculiar position in the present work. The total number of species listed for this region is greater than that for any other group except the Crustacea. There are 247(+6 ?) species[a] representing 188(+2 ?) genera and 99 families. Only a very small proportion of these (30 species) have, however, been taken in the dredge, owing, first, to the fact that the great majority of the species do not ordinarily lie upon the bottom, and, secondly, to the fact that even the largest dredges and trawls which were employed were not well adapted to retaining active fishes. In general, we may say that this Survey has dealt only incidentally with the fishes, since the latter do not, for the most part, belong to the benthos, any more than do the Medusæ and free-swimming Crustacea. Our knowledge of the distribution of fishes within the narrow limits of such a small body of water, and of the causes determining this distribution, could be substantially increased only by the use of quite other implements than the dredge. As regards the catalogue, on the other hand, it seems likely that the list of local fishes as a whole is more complete than that of any other extensive group of organisms. And even our dredging has resulted in the capture of one fish which was not previously known south of Cape Cod. This was the little blennioid species, *Ulvaria subbifurcata*.

For the past 40 years Mr. Vinal Edwards, throughout the year, and various naturalists, during the summer months, have been engaged in an active search for new fishes. To the extraordinary zeal of Mr. Edwards and his rare power of observing small differences and recognizing unusual species has been due, in large measure, the completeness of our knowledge of local fishes. As early as 1873 Prof. Baird published a list of Woods Hole fishes, some of which had already been recorded for local waters by Storer many years before. This list has received continual additions from year to year in various publications of the United States Fish Commission. In 1898, Dr. H. M. Smith brought together all the previously published records relating to local fishes together with a large number of additional ones, and prepared the most complete list

[a] Two species of marsipobranchii have been included with the true fishes in this computation.

thus far presented. This contained over 200 species of marine fishes. In several supplementary lists and special notes Dr. Smith has amplified this catalogue.[a]

In 1908 Kendall published a "List of the Pisces" for the "Fauna of New England," series of the Boston Society of Natural History, but few changes or additions were made as regards the fishes of the vicinity of Woods Hole. All this material, together with many new data and a few entirely new records for species, have been summarized in the annotated list included in the present report.[b] In the preparation of the latter considerable collections of unpublished notes by Mr. Edwards were examined, and he himself was continually questioned throughout the progress of the work. The data contributed by Mr. Edwards were based (1) on records from the fish traps operated by the Bureau of Fisheries in the neighborhood of the Woods Hole station; (2) on records from the fyke nets, which have been set during the fall, winter, and spring in both the harbors of Woods Hole; (3) on the records of innumerable seining trips made at various times of the year, but particularly in the summer months; (4) the collections made by the tow net suspended from the end of the pier (furnishing records of the occurrence of young fishes); and (5) from specimens or information received from fishermen throughout all of the local waters. Most of the specimens collected during the dredging operations, and many more which were caught in other ways during this period, were identified by the authors of this report. Those concerning which any doubt was felt were referred to the ichthyologists of the Bureau of Fisheries. To Dr. H. M. Smith and Dr. W. C. Kendall we are indebted for a critical examination of our check list of fishes.

In our list of species are comprised 2 Marsipobranchii, 26 Selachii, and 219(+4?) Teleostomi. In our comparative table (p. 89) it will be seen that the fishes have been included in only two of the other faunal catalogues therein considered. Herdman records 134 species for the Irish Sea, i. e., hardly more than half the number comprised in our own catalogue, while Graeffe lists 181 species for the Gulf of Trieste. Here, as elsewhere, it would be interesting to know how largely these differences in the number of species are actual and how largely they are due to the thoroughness of the collecting and recording. It must be borne in mind that our own list comprises a large number of species which are not indigenous, being stragglers, whose presence in our waters is due to the proximity of the Gulf Stream. The number of such exotic species is probably peculiarly high in our region.

Owing to the small number of species taken by the dredge and to the comparative paucity of the records even for such as were taken, the data thus gained relating to the local distribution of these species have not been very impressive. In general we may say, however, that while some species appeared to have an unrestricted distribution in local waters, many more fishes were taken in Vineyard Sound than in Buzzards Bay; likewise that a number of species occurred wholly or mainly at the western end of the Sound.[c]

[a] See bibliographic list for the faunal catalogue, p. 791.

[b] The records of Cope (1870) for Newport have been included here, although they were not considered by Smith, who limited the "vicinity of Woods Hole" to a somewhat smaller area than the "Woods Hole Region" of the present report.

[c] It is likely that this latter fact is in a certain measure due to the greater frequency with which the beam trawl was employed upon the sandy bottoms at the western end of Vineyard Sound. This instrument was obviously better adapted to catching and retaining fishes than were the other types of dredge employed.

There is no evidence whatever for distribution in accordance with temperature within the narrow limits of the present region. Most of the species taken in the dredge are ones which have a more or less extended northerly as well as southerly range along the coast, and it so happens that *Pholis gunnelus*, the only strictly northern species which was dredged with any frequency, was taken at scattered stations throughout most of the Sound, but was not recorded from its western end. It is quite likely that the local distribution of this fish is limited by the character of the bottom (by preference stony) and by the occurrence of certain algæ. Those fishes which are recorded with greatest frequency at the western end of the Sound are mainly species of flounders and skates, which occur predominantly on sandy bottoms. Of the five species thus restricted (*Raja erinacea*, *Lophopsetta maculata*, *Paralichthys oblongus*, and, to a less extent, *Paralichthys dentatus* and *Pseudopleuronectes americanus*), two are predominantly southward ranging, while the other three have ranges which extend about equally in both directions. Thus the character of the bottom in this western area of Vineyard Sound is doubtless responsible directly or indirectly for the distribution of these fishes. The case is quite different from that of many other organisms which have been considered by us, whose presence near the open end of the Sound is to be explained by reference to the lower water temperature which obtains there.

Even if we had a full and accurate knowledge of the local distribution of these various fishes, we should hardly expect to find the same dependence upon temperature conditions as was found in the case of some other organisms. Since fishes are free to move from place to place according to their needs, they are not subject to the constant influence of any set of conditions acting throughout the entire life cycle, as is the case with fixed or slowly moving organisms. It may well be (see pp. 175–177) that the restricting effects of a colder or warmer environment in relation to distribution depend in many instances upon its action during the reproductive period alone, and that the adult organism itself might be able to thrive under conditions unfavorable to its early development or to its reproductive activity. Indeed it is likely that such a possibility is often realized in the case of animals having sufficient powers of locomotion. And it is perhaps among the fishes themselves, many of which migrate to warmer waters for the purposes of reproduction, that the best examples may be found.

The distribution of most fishes within the narrow limits of such a region as the present one is doubtless determined chiefly by the occurrence of their food supply. This we may say with a high degree of probability, although we may not be able to determine many definite cases of correlation between the occurrence of particular species of fishes and the particular organisms which serve as their food. In the case of such predominantly bottom dwelling species as the flounders and the skates, it seems very probable that the character of the bottom is an independent factor in determining distribution. Such fishes require beds of comparatively clear sand, upon which they rest or under which they may find concealment.

The following is a list of the species of fishes recorded during the survey dredging. The asterisk, here as elsewhere, denotes those species which were taken at 10 or more stations.

*Raja erinacea (chart 198).
Gasterosteus aculeatus.
*Syngnathus fuscus (chart 199).
*Ammodytes americanus (chart 200).
Poronotus triacanthus.
Centropristes striatus.
*Stenotomus chrysops (chart 201).
*Tautogolabrus adspersus (chart 202).
Monacanthus hispidus.
*Spheroides maculatus (chart 203).
*Myoxocephalus æneus (chart 204).
Myoxocephalus octodecimspinosus.
Hemitripterus americanus.
Cyclopterus lumpus.
Neoliparis atlanticus.
*Prionotus carolinus (chart 205).
Gobiosoma bosci.
*Pholis gunnellus (chart 206).
Ulvaria subbifurcata.
Zoarces anguillaris.
Merluccius bilinearis.
Urophycis regius.
Urophycis tenuis.
Urophycis chuss.
*Paralichthys dentatus (chart 207).
*Paralichthys oblongus (chart 208).
Limanda ferruginea.
*Pseudopleuronectes americanus (chart 209).
*Lophopsetta maculata (chart 210).
Lophius piscatorius.

The 13 most common species which were taken in the dredge may be grouped as follows in respect to their known geographical range: Predominantly northern, 2; predominantly southern, 5; approximately equal, 6. The ranges for these species will not be stated here, since these are given in the table below, which gives the distribution of all our local species.

Leaving the consideration of these few species which were taken with the dredge and passing to a consideration of the entire array of species which have been reported from the vicinity of Woods Hole, we may say that our local fish fauna is overwhelmingly southern in its character. In the subjoined lists the Woods Hole fishes have been grouped into (1) those which are predominantly northward ranging; (2) those which are predominantly southward ranging; and (3) those which have an approximately equal range in both directions or regarding which the data are not sufficiently known. The distributions here stated are taken in the main from Jordan and Evermann's "Fishes of North and Middle America," supplemented by data published by H. M. Smith and by W. C. Kendall.

It will be seen that only 29 species, or less than 12 per cent of the entire number, are grouped among the northward-ranging forms, while over 75 per cent are grouped among the southward-ranging forms. The remaining 13 per cent can not well be classed in either division, and they have accordingly been grouped by themselves.

Viewing these data in another way, it will be seen that nearly half of the total number of species (48 per cent) have not been recorded from any point north of Cape Cod. In this connection allowance must of course be made for the possibility that the frequent appearance of Cape Cod as the northern limit of distribution, according to published reports, results largely from the circumstance that the fishes of Cape Cod and vicinity have been more fully listed than those of almost any other point on the coast. An equally diligent search of the waters to the northward will probably reveal the presence of many species which have hitherto been supposed to be limited by this barrier.[a]

[a] For example, Kendall (1908) records a number of species for northern New England, which by Jordan and Evermann were not listed for points to the north of Cape Cod.

Again, it is true that a very large number of the species which have been recorded for the Woods Hole region do not really belong to our local fauna at all, but are to be regarded as occasional stragglers which probably follow the Gulf Stream hither from the tropical or semitropical seas. Such without exception are the barracudas (Sphyrænidæ), pompanos (*Trachynotus*), groupers (*Epinephelus*, *Garuppa*, *Mycieroperca*), snappers (*Lutianus*), parrot-fishes (*Scarus*, *Sparisoma*), butterfly-fishes (*Chætodon*), surgeon-fishes (*Teuthis*), trunk-fishes (*Lactophrys*), and the sargassum-fish (*Pterophryne histrio*); together with most of the flying-fishes (*Exocœtidæ*), drums (*Sciænidæ*), and many others.

But the list of southward-ranging species is likewise seen to comprise the greater number of our most familiar local fishes, both the permanent residents and the "migratory" species, which are only observed during half of the year or less.

Of the northern species less than half are taken with any frequency in local waters. To this group belong most of the sticklebacks and sculpins, the lumpsucker and "sea snails," all of the "blenniform" fishes (*Pholis*, *Ulvaria*, *Cryptacanthodes*, *Anarhichas*, *Zoarces*, *Lycodes*), about half of the Gadidæ, three of the flounders, and several others. It is quite likely that in the deep, cold waters offshore other representatives of the northern fish fauna would be taken.

The following table includes all of the identified species comprised in our annotated list, grouped according to their known range as northern or southern.

Species having a predominantly northward range (29).

Myxine glutinosa	North Atlantic, south to Cape Cod; one record off Delaware.
?Cetorhinus maximus	Arctic seas, straying as far as Virginia.
Raja ocellata	Eastport to New York.
Salmo salar	Hudson Bay to Cape Cod; formerly in Hudson River and Delaware River.
Pungitius pungitius	Arctic Sea to Long Island.
Gasterosteus aculeatus	Labrador to New Jersey.
Gasterosteus bispinosus	Bay of Fundy to Woods Hole and perhaps Connecticut.
Tautogolabrus adspersus	Labrador to Sandy Hook.
Sebastes marinus	Greenland to New Jersey.
Myoxocephalus grœnlandicus	Greenland to New York.
Myoxocephalus octodecimspinosus	Labrador to Virginia.
Hemitripterus americanus	Labrador to New York.
Cyclopterus lumpus	North Atlantic south to New York.
Neoliparis atlanticus	Newfoundland to Cape Cod; Woods Hole.
Liparis liparis	Spitzbergen to Connecticut.
Pholis gunnellus	Labrador to Bridgeport, Conn.
Ulvaria subbifurcata	North Atlantic south to Cape Cod; Vineyard Sound.
Cryptacanthodes maculatus	Labrador to Long Island Sound.
Anarhichas lupus	North Atlantic south to Cape Cod; Narragansett Bay.
Zoarces anguillaris	Labrador to Delaware.
Lycodes reticulatus	Greenland to Narragansett Bay.
Pollachius virens	North Atlantic south to Cape Cod; Long Island Sound.
Microgadus tomcod	Labrador to Virginia.
Rhinonemus cimbrius	North Atlantic south in deep water to the Gulf Stream.
Gaidropsarus argentatus	Greenland to Vineyard Sound.
Brosmius brosme	North Atlantic south to Cape Cod; off Newport.
Hippoglossus hippoglossus	Northern seas southward to Sandy Hook.
Hippoglossoides platessoides	North Atlantic south to Cape Cod; Rhode Island.
Limanda ferruginea	Labrador to New York.

Species having a predominantly southward range (190).

Mustelus canis	Salem, Mass., to Cuba.
Galeocerdo tigrinus	Cape Cod to tropical seas.
Prionace glauca	Woods Hole southward; warm seas.
Carcharhinus obscurus	Nahant to North Carolina.
Carcharhinus milberti	Cape Cod to Florida.
Carcharhinus limbatus	Woods Hole (stray specimens) to Brazil.
Sphyrna zygæna	Cape Cod to warm seas.
Alopias vulpes	Eastport to warm seas.
Carcharias littoralis	Casco Bay to North Carolina
Isurus dekayi	Casco Bay to West Indies.
Carcharodon carcharias	Eastport to tropical seas.
Squalus acanthias	Canada to Cuba.
Squatina squatina	Cape Cod to Florida.
Raja eglanteria	Gloucester to Florida.
Raja lævis	Eastport to Florida.
Tetronarce occidentalis	Casco Bay and perhaps Nova Scotia to Cuba.
Dasyatis centrura	Coast of Maine to Cape Hatteras.
?Dasyatis hastata	Chatham to Brazil.
Pteroplatea maclura	Woods Hole to Brazil.
Myliobatis freminvillei	Cape Cod to Brazil.
Rhinoptera bonasus	Cape Cod to Florida.
Acipenser sturio	Penobscot River to Charleston.
Felichthys marinus	Cape Cod to Texas.
Galeichthys felis	Cape Cod to Texas.
Anguilla rostrata	Gulf of St. Lawrence to Mexico.
Leptocephalus conger	Maine to Brazil.
Muræna retifera	Tuckernuck Island to coast of South Carolina.
Tarpon atlanticus	Buzzards Bay to Brazil.
Elops saurus	Woods Hole to tropical seas.
Albula vulpes	Woods Hole to tropical seas.
Etrumeus teres	Cape Cod to Gulf of Mexico.
Clupanodon pseudohispanicus	Cape Cod to Gulf of Mexico.
Pomolobus mediocris	Maine to Florida.
Alosa sapidissima	Gulf of St. Lawrence to Alabama.
Opisthonema oglinum	Vineyard Sound to West Indies.
Brevoortia tyrannus	Nova Scotia to Brazil.
Anchovia brownii	Cape Cod to Brazil.
Anchovia argyrophanus	Gulf Stream; occasional northward to Woods Hole, Mass.
Anchovia mitchilli	Casco Bay to Texas.
Trachinocephalus myops	Woods Hole to Brazil.
Synodus fœtans	Cape Cod to Brazil.
Fundulus majalis	Salem to Florida.
Fundulus heteroclitus	Coast of Maine to Rio Grande.
Lucania parva	Woods Hole to Key West.
Cyprinodon variegatus	Cape Cod to Rio Grande.
Tylosurus marinus	Casco Bay to Texas.
Tylosurus acus	Buzzards Bay (occasional) to West Indies.
Athlennes hians	Woods Hole to Brazil.
Hyporhamphus roberti	Woods Hole to Panama.
Hemirhamphus brasiliensis	Woods Hole to Brazil.
Euleptorhamphus velox	Massachusetts to West Indies.
Parexocœtus mesogaster	West Indies; north in the Gulf Stream to Newport.
Exocœtus rondeletii	Vineyard Sound to tropical seas.

Exocœtus volitans	Banks of Newfoundland to West Indies.
Cypselurus heterurus	Banks of Newfoundland to southern coast of United States.
Cypselurus furcatus	Cape Cod to warm seas.
Fistularia tabacaria	Rockport, Mass., to West Indies.
Syngnathus fuscus	Eastport to North Carolina.
Hippocampus hudsonius	Massachusetts Bay? to Charleston.
Menidia beryllina cerea	Sandwich, Mass., to South Carolina.
Mugil cephalus	Casco Bay to Brazil.
Mugil curema	Cape Cod to Brazil.
Sphyræna barracuda	Woods Hole to Brazil.
Sphyræna guachancho	Woods Hole (occasional) to West Indies.
Sphyræna borealis	Cape Cod to Cape Fear.
Polydactylus octonemus	Woods Hole to the Rio Grande.
Holocentrus tortugæ	(?)
Mullus auratus	Cape Cod to Pensacola, Fla.
Auxis thazard	Cape Cod (occasional) to warm seas.
Gymnosarda pelamis	Cape Cod to warm seas.
Gymnosarda alleterata	Cape Cod (occasional) to West Indies.
Thunnus thynnus	Newfoundland to Caribbean Sea.
Germo alalunga	Woods Hole to tropical seas.
Sarda sarda	Harpswell, Me., to Hatteras.
Scomberomorus maculatus	Maine to Brazil.
Scomberomorus regalis	Cape Cod to Brazil.
Scomberomorus cavalla	Cape Cod to Brazil.
Trichiurus lepturus	Maine to West Indies.
Istiophorus nigricans	Woods Hole to West Indies.
Tetrapterus imperator	Cape Cod (occasional) to West Indies.
Xiphias gladius	Cape Breton to Cuba.
Oligoplites saurus	Woods Hole to West Indies.
Naucrates ductor	Maine to West Indies.
Seriola zonata	Salem, Mass., to Cape Hatteras.
Seriola lalandi	Woods Hole to Brazil.
Seriola dumerili	Woods Hole to West Indies.
Decapterus punctatus	Cape Cod to Brazil.
Decapterus macarellus	Cape Cod to warm parts of Atlantic.
Trachurus trachurus	Newport; Pensacola.
Trachurops crumenophthalmus	Cape Cod (occasional) to West Indies.
Carangus bartholomæi	Woods Hole to West Indies.
Carangus hippos	Lynn to tropical America.
Carangus crysos	Ipswich Bay, Mass., to Brazil.
Alectis ciliaris	Cape Cod to tropical America.
Vomer setipinnis	Maine to Brazil.
Selene vomer	Casco Bay to Brazil.
Trachinotus falcatus	Cape Cod to Brazil.
Trachinotus goodei	Woods Hole to West Indies.
Trachinotus argenteus	Woods Hole to West Indies.
Trachinotus carolinus	Cape Cod to Gulf of Mexico.
Rachycentron canadus	Cape Cod to warm seas.
Nomeus gronovii	Woods Hole to tropical Atlantic.
Coryphæna hippurus	Cape Cod to Texas.
Palinurichthys perciformis	Maine to Cape Hatteras.
Peprilus paru	Cape Cod to Brazil.
Poronotus triacanthus	Nova Scotia to Florida.
Apogon imberbus	Mediterranean and neighboring waters; Brazil.
Apogon maculatus	Marthas Vineyard to Brazil.

Roccus lineatus................New Brunswick to Florida.
Morone americana..............Nova Scotia to South Carolina.
Epinephelus adscensionis.......Marthas Vineyard to Brazil.
Epinephelus niveatus..........Woods Hole to Brazil.
Epinephelus morio.............Marthas Vineyard to Brazil.
Garrupa nigrita................Marthas Vineyard to Brazil.
Mycteroperca bonaci...........Marthas Vineyard to Brazil.
?Mycteroperca interstitialis.....Marthas Vineyard to Cuba.
Centropristes striatus...........Maine to Florida.
Rypticus bistrispinus...........Newport to Key West.
Lobotes surinamensis...........Cape Cod to warm seas.
Priacanthus arenatus...........Woods Hole to Brazil.
Pseudopriacanthus altus.........Marblehead, Mass., to West Indies.
Lutianus griseus................Woods Hole to Brazil.
Lutianus jocu...................Woods Hole (occasional) to Brazil.
Lutianus apodus................Woods Hole (rare) to Brazil.
Lutianus blackfordii...........Woods Hole (occasional) to Brazil.
Lutianus analis.................Woods Hole (occasional) to Brazil.
Ocyurus chrysurus..............Marthas Vineyard to Brazil.
Orthopristis chrysopterus........Marthas Vineyard to Rio Grande.
Stenotomus chrysops............Eastport, Me., to South Carolina.
Lagodon rhomboides............Cape Cod to Cuba.
Archosargus probatocephalus...Cape Cod to Texas.
Eucinostomus gula.............Woods Hole to Brazil.
Kyphosus sectatrix.............Cape Cod to West Indies.
Kyphosus incisor...............Nantucket to Brazil.
Cynoscion regalis ....Maine to Gulf of Mexico.
Larimus fasciatus...............Woods Hole (occasional) to Texas.
Sciænops ocellatus.............Buzzards Bay to Texas.
Leiostomus xanthurus..........Cape Cod to Texas.
Micropogon undulatus..........Cape Cod to Texas.
Menticirrhus saxatilis..........Casco Bay to Florida.
Pogonias cromis................Provincetown to Rio Grande.
Eupomacentrus leucostictus....Marthas Vineyard to West Indies.
Abudefduf saxatilis.............Newport to Uruguay.
Tautoga onitis..................New Brunswick to Charleston, S. C.
Sparisoma flavescens...........Woods Hole to Rio Janeiro.
Scarus croicensis...............Marthas Vineyard to West Indies.
Chætodipterus faber............Cape Cod to Rio Janeiro.
Chætodon ocellatus.............Woods Hole to West Indies.
Chætodon capistratus...........Woods Hole to West Indies.
Teuthis cæruleus...............Marthas Vineyard to Brazil.
Teuthis hepatus................Marthas Vineyard to Brazil.
Teuthis bahianus...............Marthas Vineyard to Brazil.
Balistes carolinensis............Annisquam, Mass., to tropical Atlantic.
Balistes vetula.................Woods Hole (occasional) to West Indies.
Balistes forcipatus..............Newport (?) to Brazil.
Canthidermis sobaco...........Vineyard Sound to West Indies.
Monacanthus hispidus..........Lynn, Mass., to Brazil.
Alutera schœpfii...............Portland, Me., to Texas.
Alutera monoceros.............Woods Hole to West Indies.
Lactophrys triqueter...........Marthas Vineyard to West Indies.
Lactophrys trigonus............Woods Hole to West Indies.
Lactophrys tricornis............Marthas Vineyard to tropical Atlantic.
Lagocephalus lævigatus........Cape Cod to Brazil.

Spheroides spengleri	Woods Hole to Rio Janeiro.
Spheroides maculatus	Casco Bay to Florida.
Spheroides testudineus	Newport to West Indies.
Diodon hystrix	Buzzards Bay to tropical seas.
Chilomycterus schœpfi	Massachusetts Bay to Florida.
Chilomycterus antillarum	Woods Hole; Cuba and Jamaica.
Mola mola	Off Portland, Me., to tropical seas.
Scorpæna plumieri	Marthas Vineyard to Brazil.
Scorpæna grandicornis	Marthas Vineyard to Brazil.
Prionotus carolinus	Maine to South Carolina.
Prionotus strigatus	Salem, Mass., to Virginia.
Cephalacanthus volitans	Maine to Gulf coast.
Gobius stigmaticus	Marthas Vineyard to Rio Janeiro.
Gobiosoma bosci	Cape Cod to Florida.
Echeneis naucrates	Salem, Mass., to warm seas.
Remora remora	Salem to West Indies.
Remora brachyptera	Massachusetts Bay to warm seas.
Rhombochirus osteochir	Cape Cod to West Indies.
Lopholatilus chamæleonticeps	Deep waters of the western Atlantic.
Opsanus tau	Massachusetts Bay, perhaps Maine, to Cuba.
Macrourus bairdii	Eastport to West Indies.
Paralichthys dentatus	Casco Bay to Florida.
Lophopsetta maculata	Eastport to South Carolina.
Platophrys ocellatus	Marthas Vineyard to Rio Janeiro.
Achirus fasciatus	Cape Ann to Texas.
Gymnachirus nudus	Woods Hole; Brazil.
Pterophryne histrio	Woods Hole to tropical Atlantic.

Species having an approximately equal range to the north and south, and ones whose range is not definitely known (32).

Petromyzon marinus	Eastport to North Carolina.
?Lamna cornubica	North Atlantic; occasionally taken on coast of New England and southward.
Raja erinacea	Maine to Virginia.
Raja radiata	North Atlantic.
Clupea harengus	North Atlantic Ocean, chiefly north of Cape Hatteras.
Pomolobus pseudoharengus	Atlantic coast of the United States.
Pomolobus æstivalis	Atlantic coast; Eastport; Southern States.
Salvelinus fontinalis	Labrador to Georgia.
Osmerus mordax	Gulf of St. Lawrence to Virginia.
Maurolicus pennanti	Open seas, occasionally off New England coast.
Fundulus diaphanus	Coast of Maine to Cape Hatteras.
Scombresox saurus	Newfoundland to Beaufort.
Cypselurus gibbifrons	Only two specimens known.
Apeltes quadracus	Maine to New Jersey.
Menidia menidia notata	Nova Scotia to North Carolina.
Ammodytes americanus	Newfoundland to Cape Hatteras.
Scomber scombrus	Labrador to Cape Hatteras.
Scomber colias	Maine; England to Mediterranean; Pacific Ocean.
Pomatomus saltatrix	Atlantic and Indian Oceans, widely distributed.
Brama raii	Open seas, widely distributed.
Centrolophus niger	Coasts of southern Europe.
Tetragonurus cuvieri	Open Atlantic; off Toulon and Marseilles and near Madeira.
Myoxocephalus æneus	Casco Bay to New York.
Merluccius bilinearis	Straits of Belle Isle to Bahamas.

Gadus callarias................	North Atlantic, south to Virginia; North Carolina.
Melanogrammus æglefinus......	North Atlantic, south to North Carolina.
Urophycis regius..............	North Atlantic, south to Charleston, S. C.
Urophycis tenuis..............	Banks of Newfoundland to Cape Hatteras.
Urophycis chuss...............	Gulf of St. Lawrence to Virginia.
Paralichthys oblongus..........	Coasts of New England and New York.
Pseudopleuronectes americanus.	Labrador to Chesapeake Bay; Georgia.
Lophius piscatorius............	Nova Scotia, in deep water, to Barbados.

13. REPTILIA, AVES, MAMMALIA.

These groups have been included in our catalogue for the sake of completeness, though they occupy a very different position in our marine fauna from any of the groups which have thus far been discussed.

Of the reptiles, five species have been listed, of which only three are to be regarded as marine in the strict sense of the word. These are the sea turtles, which are occasionally taken in fish traps or otherwise during the summer months. We are indebted to Dr. Leonhard Stejneger for criticizing our manuscript list of Reptilia and for aiding us in the identification of one species.

Of the birds, only swimming species which are known to frequent salt water have been listed. In some cases it has not been easy to decide whether or not a given bird should be regarded as "marine." In the preparation of this list we have received much help from Dr. G. M. Allen and Prof. Lynds Jones. Dr. Allen has kindly examined the manuscript of our check list. The nomenclature of the American Ornithologists' Union has been adopted without modification. In the preparation of this list, as in many other parts of our work, we have received substantial assistance from Mr. Vinal Edwards, who has for many years collected birds at Woods Hole.

With the exception of the muskrat, mink, and seals, the mammals of our list are all Cetacea. The source of these records has been indicated in the list itself. Very few of these animals are seen with any frequency in the neighborhood of Woods Hole. Indeed some of the whales have not been noted within the region for many years. We are indebted to Dr. F. W. True for a number of the records for species, as well as for criticizing our manuscript.

Chapter V. THEORETICAL CONSIDERATIONS.

1. FACTORS DETERMINING DISTRIBUTION.

As a result of our labors, the distribution patterns of a large number of species have been portrayed graphically. Even if these were offered merely as empirical facts, without any attempt at an explanation, we feel that their publication would be fully justified. But many of these distribution patterns are not purely empirical. On the contrary they stand in evident relation to certain physical factors in the environment. The nature of these factors has been already discussed rather fully in chapter II, and concrete examples of their influence upon distribution have been instanced repeatedly in chapter IV. The factors which we believe to be most effective directly and indirectly in determining the distribution of the bottom-dwelling species throughout these waters are (1) the character of the bottom, considered chiefly in relation to its physical texture; and (2) the temperature of the water. To these we may add another factor of far less extended application, so far as concerns our dredging results. This is (3) depth of water, or, perhaps, more strictly, proximity to shore, though this statement demands considerable explanation.

We are quite aware that several other factors are generally recognized[a] as being of importance in determining the distribution of marine organisms; and we do not wish to be understood as limiting these agencies to the ones here enumerated. But we are concerned at present only in explaining the phenomena encountered by us during our dredging operations in the vicinity of Woods Hole. The factor of salinity is doubtless of the highest importance in determining the fauna of salt marshes and estuaries, and even that of the open sea near the mouths of rivers.[b] But there are, within the limits of our region, no streams of sufficient magnitude to seriously affect the fauna at any considerable distance from shore. Among all the species taken in the course of our dredging, we have encountered not more than two or three which seemed to be restricted to the upper portions of Buzzards Bay, where alone the water was found to be diluted in any considerable degree (cf. charts 215-218). The most striking case of this sort was that of the sponge *Tethya gravida*, which, so far as we know, has only been taken near the head of Buzzards Bay.

The presence or absence of other organisms, which may serve as the food of a given species or which may furnish it with a necessary basis for attachment, is surely to be ranked as an important factor in influencing distribution. But these other organisms are, in turn, dependent upon inorganic factors, such as those which we have mentioned, and thus the latter may be regarded as ultimately responsible for the distribution in all cases.

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[a] For admirable general discussions of this subject the reader is referred to C. G. J. Petersen (1893), Herdman et al. (1894), Walther (1894), and Allen (1899).

[b] Certain marine fishes have been held to be sensitive, directly or indirectly, to comparatively slight differences in the density of their surrounding medium. Petterssen (1894) has shown that the appearance of herring upon the Norwegian coast is correlated with periodic changes of water salinity; but since the latter changes are simultaneous with changes in the temperature and in the food supply, it would seem difficult to exclude the influence of these latter factors. On the contrary, it is well known (vide Sumner, 1906, p. 68) that many marine fishes are capable of living equally well in waters of widely different degrees of salinity.

2. THE LOCAL FAUNA AS INFLUENCED BY THE CHARACTER OF THE BOTTOM.

Of the three factors enumerated above, the first (character of bottom) is beyond doubt the most effective one in determining the distribution of organisms within the limits under consideration by us. It is a mere truism that solid objects are necessary for the attachment of whole groups of fixed organisms, e. g., hydroids, Bryozoa, ascidians, barnacles, etc., as well as of many algæ. The presence of stones or shells is therefore essential to the existence of such forms. The absence of a suitable basis of support we believe to account in the main for the comparative scarcity of hydroids in Buzzards Bay. Soft mud doubtless interferes, likewise, with the respiratory currents of many organisms, and these, too, would be better fitted to live in Vineyard Sound. Other forms, on the contrary, require a muddy bottom in which to burrow. Thus, many of our local annelids and certain bivalve mollusks are, for the most part, restricted to Buzzards Bay. In some cases, as stated above, the relation between fauna and bottom is less direct, as witness the small tube-dwelling worms of the genus *Spirorbis*, which commonly adhere to various algæ.

Since, as we have seen, Vineyard Sound and Buzzards Bay are rather sharply distinguished from each other by the presence or absence of mud on the one hand, and of clean sand and gravel on the other, it is natural that the most obvious distinction in distribution should be that between the predominantly Sound-dwelling species and the predominantly Bay-dwelling species. By reference to the lists of species contained in chapter III it will be found that 40 per cent of the more prevalent species dredged by the *Fish Hawk* in Buzzards Bay do not appear in the list of the more prevalent species dredged by the *Fish Hawk* in Vineyard Sound; while 35 per cent of the species contained in the latter list do not appear among the former. Our distribution charts, likewise, reveal the occurrence of many species which are restricted wholly or chiefly to Vineyard Sound, and a considerable number of others which are restricted wholly or chiefly to Buzzards Bay.

Furthermore, within each of these major bodies of water, the local distribution of many forms is very obviously determined by the presence of one or another variety of bottom. Thus it happens that many species whose occurrence in Vineyard Sound is general are found in Buzzards Bay only in the adlittoral zone, particularly along the Elizabeth Islands. Here the mud is less prevalent, and the bottom approximates in character much of that to be met with in Vineyard Sound. A type of distribution which is almost the converse of the last is met with in the case of certain mud-dwelling species, which are of general occurrence throughout the bottom of Buzzards Bay, but which in Vineyard Sound are confined to a few definite areas where mud is known to be present (e. g., *Yoldia limatula*, chart 135). Vineyard Sound is divisible, as has been already stated, into an eastern half, in which the bottom is predominantly gravelly and stony, and a western half, in which the bottom is mainly of sand (see chart 227). Accordingly, many species, particularly among the attached forms, are lacking in the western half of the Sound, except in the littoral and adlittoral zones; while certain sand-dwelling species (e. g., the "lady crab," *Ovalipes ocellatus*, and among fishes the rays and flounders) are especially prevalent in that very region. Such cases as these are not always easy to distinguish from those to be discussed presently, in which temperature determines which half of the Sound is inhabited by a given species. The lower

end of Buzzards Bay, like its eastern shore, is comparatively free from deposits of mud, and accordingly we often meet with species here which occur in various parts of the Sound, but which are rarely or never met with in the more central parts of the Bay. Here again the temperature factor often leads to similar appearances, and it is therefore necessary to consider the total range of a species before we can form any definite conclusions as to which factor is responsible in a given case.

The scarcity or apparent total absence in Buzzards Bay of a considerable number of species belonging to each of the subkingdoms is, we believe, due chiefly if not entirely to the character of the bottom. It is true that the annual extremes of temperature are somewhat greater in the Bay than in the Sound, and it is true that the water density of the former is slightly lower; but we would attribute little importance to these factors in determining the differences in their respective faunas.

Tables presented in chapter III show that the list of prevalent species for the *Fish Hawk* stations in Buzzards Bay is almost identical with that for muddy bottoms; while the list of prevalent species for the *Fish Hawk* stations in Vineyard Sound includes but two species which were not contained either in the list for sandy or in that for gravelly bottoms. This, however, can hardly be regarded as *independent* evidence that the differences in fauna between the two bodies of water are due to differences of the bottom.

As regards the variety of life found to occur upon the various types of bottom, it was shown above that the number of species per dredge haul was greatest for the bottoms of gravel or stones and least for the sandy bottoms, while the muddy bottoms held an intermediate position in this respect. It was pointed out, however, that the greater wealth in species, recorded for the muddy bottoms, as compared with the sandy ones, might be due, in part at least, to the fact that the dredge cut more deeply into the former, and thus obtained a fairer representation of the burrowing organisms.

It was likewise shown statistically that the average number of species per dredge haul was greater in Buzzards Bay than in Vineyard Sound. This was true despite the fact that the total number of species encountered was much greater in the Sound than in the Bay. We have interpreted these facts as signifying that while the wealth of species is, on the average, as great or even greater at each particular point on the floor of Buzzards Bay, the greater diversity of conditions in Vineyard Sound as a whole results in its furnishing a habitat to a greater variety of species.[a] This conclusion is quite in harmony with the fact that the number of "prevalent" species for Buzzards Bay—i. e., the number of those taken at one-fourth or more of the dredging stations—is about the same (slightly greater, indeed) than the similar number for Vineyard Sound. On the assumption of a greater uniformity of life conditions throughout the former, a larger proportion of the Bay-dwelling species might be expected to occur at one-fourth or more of the stations, even though the total number of such species were smaller.

We think that the reader will be impressed, as are we, by the approximate agreement among the figures representing the wealth in species of the different types of bottom distinguished by us and of the different subdivisions of the area dredged. The figures (p. 77) denoting the average number of species per dredge haul range from 35.2 for the *Phalarope* stations in Vineyard Sound to 39.7 for the Crab Ledge stations, the mean for all the stations being 37.0. Again, the lists of more "prevalent" species for various

[a] See, however, discussion on pp. 79, 80, which renders this conclusion somewhat uncertain.

habitats and regions are of approximately equal length, the number of species ranging, with a single exception, between 50 and 55. These figures, of course, in no way express the relative *wealth of animal life* in these situations, this last being dependent upon the number of *individuals* rather than the number of species. Unfortunately we have no data sufficient for the purpose of giving a statistical expression to the real wealth of life upon different portions of the local sea floor. Particular spots were found, it is true, which were in large degree destitute of life, but whether or not any one of the types of bottom or of the larger subdivisions of our region was more densely populated than any other can not be stated with mathematical certainty. It is our general impression that living organisms were found to be somewhat less abundant upon bottoms of comparatively pure sand, although it is true that this is the prevailing type of bottom in the western portion of Vineyard Sound, to which many of our species are restricted.[a]

Another fact which may be regarded as surprising, despite the differences pointed out above, is the comparatively small proportion of the species which are restricted to any particular type of bottom. Thirty species are common to all three of the lists which give the prevalent forms for each type of bottom, this number representing, on the average, 60 per cent of the number contained in each list. But even this figure does not fairly express the number of those which were actually found with considerable frequency upon all three types of bottom, since each list is restricted to species so common as to have been encountered at one-fourth of a given group of stations. Again, only 26 per cent of the species contained in the list of prevalent mud-dwelling forms is peculiar to that list; while only 24 per cent of the list for bottoms of stones and gravel, and only 13 per cent of that for sandy bottoms are peculiar to their respective lists.

We do not think that these figures fairly express, however, the obvious differences in the characteristic faunal aggregations for different types of bottom, as presented to the eye. This is because they do not take into account the relative number of individuals belonging to the various species. Certain species which are characteristic of muddy bottoms (e. g., certain bivalve mollusks and worms) are present in great numbers in an average dredge haul made upon such a bottom. But along with them are smaller numbers of a great variety of species, which are not especially characteristic. The same may be said of the other types of bottom. Thus the real distinctness of the faunal aggregations in question could only be adequately expressed by reference to the relative abundance of each species.[b] Again it must be once more emphasized that the mixing up, in a single dredge haul, of organisms from several quite distinct bottoms is in some measure responsible for this apparent lack of distinctness in their respective habitats. This is particularly true of relatively small areas of sea floor, such as those under consideration, in which quite various deposits are found to alternate with one another at frequent intervals. It is likely, indeed, that under such circumstances there is much overlapping and intermingling of faunal aggregations which elsewhere might be far more distinct. Finally, it must be remembered that the lists of "prevalent" species, as here constituted, exclude many forms which are highly characteristic of the bottoms in question, and which, in some cases, are restricted to them.

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[a] It is here, indeed, that line fishing for mackerel and flounders is carried on with the greatest success.

[b] Of course, in a certain measure the wealth of a given species in individuals determines the frequency with which it appears in the dredging records. It is self-evident that the more abundant species are more likely to be taken than less common ones.

It would be hard to characterize in any brief statement the faunal assemblages proper to the various types of bottom. Such assemblages have been presented in four illustrative cases (p. 58–62), and composite pictures, including the more characteristic species, have been given elsewhere in chapter III. An attempt to still further condense these data would, we fear, result in a mere statement of platitudes. It may be allowable to mention, however, that the most characteristic species found upon muddy bottoms were annelids and bivalve mollusks, many of which were restricted to such bottoms; the most characteristic species found upon bottoms of stones or gravel were hydroids, Bryozoa, and ascidians; while the few species which were in any real sense restricted to bottoms of clear sand were either burrowing species (*Ovalipes*, *Echinarachnius*, certain lamellibranchs), or fishes (flounders and skates) which adhered closely to the bottom.

3. THE INFLUENCE OF TEMPERATURE.

The temperature factor is, with little doubt, the controlling one in the case of many species belonging to several different phyla. On page 74 is given a list of species which were dredged predominantly or exclusively in the colder waters of the region, i. e., at the western end of Vineyard Sound and the mouth of Buzzards Bay. Here the summer temperature of the bottom water averages about 10° F. (5.6° C.) lower than in the immediate neighborhood of Woods Hole. Reference to the stated ranges of these species revealed the fact that in 15 out of the 20 cases they are predominantly northward-ranging forms, some of which, indeed, are near their southern limit of distribution. Reference has also been made to a number of less common forms having a similar distribution, but which are not included among those for which distribution charts have been prepared. This large proportion of northward-ranging species among those occupying the colder waters of Vineyard Sound and Buzzards Bay is significant in view of the fact that a decided minority (23 per cent) of the species dredged by us with any frequency throughout the region at large are to be classed as northward-ranging, according to the standard employed.

It is of interest, also, to note that a large proportion of these colder water species were likewise taken by us at Crab Ledge, off Chatham, where the water temperatures in summer are even lower than at the mouth of Vineyard Sound. At Crab Ledge and at certain other outlying points were also taken a considerable number of species which appear never to enter Vineyard Sound or Buzzards Bay at all. So far as we have ascertained the ranges of the species, they belong, almost without exception, to the "Acadian" fauna characteristic of the waters north of Cape Cod.

Another list was presented (p. 76) of species which, though otherwise of general distribution throughout Vineyard Sound, and in many cases throughout Buzzards Bay as well, are absent from just those waters to which the northern types are restricted. This list was found to include none of the strictly northern types, while more than half of the species there included were forms which found in Cape Cod their northern limit of distribution. It is probable that the temperature factor is the one responsible for this type of distribution in some cases at least. Many of these species, it is significant to state, are conspicuously absent from Crab Ledge. On the other hand, it is likely that for some other organisms (e. g., the ascidians) the uniformly sandy condition of the bottom in this outer portion of Vineyard Sound and the scarcity of solid objects suitable for attachment render it an unfavorable habitat.

Although we believe these evidences of the distribution of local species with relation to temperature to be well-nigh conclusive, the fact must be admitted that there occur in Vineyard Sound and Buzzards Bay a considerable number of predominantly northward-ranging species, and a yet greater number of southward-ranging ones, whose distribution within local waters bears no possible relation to temperature. These are in some cases of very general occurrence; in others their distribution appears to be determined by the character of the bottom.

The actual mode of operation of temperature in restricting the distribution of species locally is not easy to state, and it is probable that no single formula is applicable to all cases. In chapter II the temperature conditions throughout local waters have been discussed rather fully. It has been shown that the temperature of those portions of Vineyard Sound and Buzzards Bay which immediately join the ocean is lower than that of the more inclosed waters for probably not more than half of the year, the difference being greatest during the summer months. It was also shown to be probable that all the waters of the region reach a point not far from the freezing point of salt water for a longer or shorter period during the winter. In the light of what we know regarding local temperature conditions on the one hand and the distribution of our marine fauna on the other, it will be of interest to consider certain theories which have been put forward to explain the part played by this factor in limiting the distribution of organisms in general.

The influence of temperature in determining the distribution of marine animals was emphasized by Forbes and by Dana more than 50 years ago, and has been accepted as almost self-evident by a large number of naturalists. Just how this factor operates in limiting the distribution of a given species is, however, far from plain. Dana,[a] in 1852, introduced the concept of "isocrymal lines," or lines showing the mean temperature of the waters along their course for the coldest 30 consecutive days of the year. Ordinary isotherms, or lines of mean annual temperature, he rejects as inadequate, on the ground that "the cause which limits the distribution of species northward or southward from the Equator is the cold of winter rather than the heat of summer or even the mean temperature of the year" (p. 1452).

Such a principle certainly does not explain the effect of temperature upon distribution within the limits of our local waters. Here the minimum winter temperatures are probably nearly the same throughout the entire region. If there are any local differences of regular occurrence, it is without doubt the shallower, more inclosed waters which attain the lowest winter temperatures. But these are precisely not the ones which are occupied by the northern forms of which we have spoken. Within local waters it is certainly the summer temperatures rather than the winter ones which are chiefly effective in limiting the distribution of species.

Verrill (1866, p. 249) maintained that for birds "the essential limiting cause is the average temperature of the breeding season, which for the majority of our birds may be taken as April, May, and June." This idea was apparently suggested by the conclusions of certain botanists respecting the distribution of plants. Merriam (1895, 1898), following out the same thought, has been led to the belief that "[land] animals and plants are restricted in northward distribution by the total quantity of heat during

[a] Dana, 1852, p. 1451–1592; 1853, p. 153–167, 317–327.

the season of growth and reproduction" (1895, p. 233); while "animals and plants are restricted in southward distribution by the mean temperature of a brief period covering the hottest part of the year" (p. 234). The phrase "total quantity of heat" above employed is not to be taken in a strict sense, however, but implies "the effective temperatures or degrees of normal mean daily heat in excess of this minimum [6° C.]" which "have been added together for each station, beginning when the normal mean daily temperature rises higher than 6° C. in spring and continuing until it falls to the same point at the end of the season" (p. 232–233). "In conformity with the usage of botanists, a minimum temperature of 6° C. (43° F.) has been assumed as marking the inception of the period of physiological activity in plants and of reproductive activity in animals" (p. 232).

It is obviously impossible without qualification to apply this principle in explaining the distribution of marine animals. Many of these, as is well known, breed during the coldest months of the year, at a time when the temperature lies considerably below that assumed by Merriam as a necessary minimum for physiological activity; and there is no general agreement in the breeding season of even closely related forms. Unfortunately, the period of sexual reproduction is not definitely known for the vast majority of our local species. The greater part of such definite observations as are available are contained in the rather meager notes of Bumpus (1898, 1898a, 1898b), Mead (1898), and Thompson (1899), which cover only the spring and summer months. For a few species, however (e. g., certain amphipods [a] and the mollusk *Littorina palliata*), we have definite evidence that eggs are laid nearly or quite throughout the year.

From the data offered by Garstang (1894) for the breeding periods of marine animals at Plymouth, England, we may make a rough computation of the percentage of the species which breed during each month of the year in those waters. The following table, based upon records for about 200 species, presents these figures:

	Per cent.		Per cent.
January	14	July	23
February	20	August	21
March	23	September	16
April	29	October	9
May	33	November	7
June	28	December	5

It is impossible to state how far these figures are representative of the total marine fauna, even at Plymouth, and how far they have depended upon the relative activity of the observers during different months, but they seem to show that a considerable proportion of the species reproduce during the coldest months of the year.[b] And it would be a safe assumption, even in the absence of such confirmatory evidence as we possess, that the same statement would hold for the region of Woods Hole.

Before the operation of Merriam's law can be accepted as a sufficient explanation of the non-occurrence of certain southern species in the colder waters of this region, it must be shown that the "season of growth and reproduction" coincides with the period during which these waters are colder. As a matter of fact, we know that a considerable

[a] One of these, *Calliopius læviusculus*, is included in the list of the cold-water, northward-ranging species, which are, in our dredging records, restricted to the western part of Vineyard Sound.

[b] It must be added, however, that the waters in the neighborhood of Plymouth never reach such low temperatures as are recorded during the winter months for Vineyard Sound and Buzzards Bay. (See p. 183, 184, below.)

number of species belonging to this category (though not these in particular) do reproduce sexually during the summer months. In few cases, if any, however, do we know from local observations that their sexual period is confined to these months. We may comment parenthetically upon the urgent need of determining the reproductive condition of local marine organisms throughout the entire year.[a]

In the case of one species among those which appear to be restricted to the warmer waters of the region we have definite evidence that an actual destruction of adult organisms may occur as a result of extreme cold in winter. We refer to the common sea urchin, *Arbacia punctulata*, which, as our records show (see pp. 114, 115), was almost exterminated in Vineyard Sound during the winter of 1903–4. And it is well known to fishermen and others that great numbers of dead fishes and mollusks of certain species are frequently found after a particularly hard spell of cold weather.[b] This is sometimes attributed to the action of "anchor ice" or "ground frost." Gould (1840) cites the case of an extensive destruction of oysters which was believed to be due to this agency. That anchor ice does form in salt water, even at the depth of a number of fathoms, and that it may "freeze around fish caught in nets," is vouched for by Sir William Dawson and others.[c] On the other hand, we are informed by Prof. Herdman that he has had personal knowledge of the death from cold of fishes in aquaria, and even of burrowing mollusks along shore, in cases where actual freezing was out of question. It seems difficult, indeed, to believe in such a wholesale formation of anchor ice throughout Vineyard Sound as would be necessary to account for the extermination of the sea urchins by this agency. However, the extermination did occur during an exceptionally cold winter, and it seems a legitimate inference that it resulted in some way from the cold.

Now it is known that *Arbacia* finds in this region its northern limit of distribution upon our coast. It would seem, therefore, that in this latitude it is adapted to withstanding the average winter but not the exceptional one. On the other hand, no mere reference to *winter* temperatures can explain the absence of this species from the western end of Vineyard Sound, or from Crab Ledge. For, although at these latter points the summer temperatures are considerably lower than they are nearer Woods Hole, the winter temperatures are no lower, and possibly, indeed, not so low. Here, then, the law of Merriam may have application. *Arbacia* may not be adapted to reproducing in these colder waters.

But Merriam's principle, in its completed form, really contains two wholly distinct principles. The second is that animals are "restricted in southward distribution by the mean temperature of a brief period covering the hottest part of the year" (1895, p. 234). It is not stated whether this effect has to do with the ability of the adult organism itself to withstand higher temperatures, or whether the reproductive power is curtailed.

As regards the distribution of our local marine fauna, this phase of Merriam's law can apply, if at all, only to those predominantly northern species which were found to be restricted to the waters which were cooler during the summer months. And it does seem likely, indeed, that some of these species are unable to endure the high temperatures

[a] Aside from the case of certain fishes, our data for the winter months are derived almost wholly from an examination of tow-net collections made by Mr. Edwards.

[b] The scraping action of ordinary floating ice in removing the rock-weeds (*Fucus* and *Ascophyllum*) from the boulders along shore is pointed out in the botanical section of this report. This same agency doubtless restricts the distribution of such littoral animals as inhabit these weeds, and may even affect certain other forms, e. g., barnacles, which occur directly on the rocks. But it can, of course, have no influence upon the benthos, with which we are especially concerned here.

[c] Cf. Barnes, 1906, p. 210, 223–225.

attained by our more inclosed waters during the hottest part of the summer. For the great majority of cases, it must be admitted that this explanation is wholly conjectural. We know of at least one species of animal, however, which occurs in an active condition throughout Vineyard Sound during the winter and spring, but which, in these waters, passes into a condition of æstivation during the summer. This is the hydroid *Tubularia couthouyi* (see p. 565). Now it is of significance that in the colder waters at Crab Ledge, and beyond Marthas Vineyard, at a depth of 29 fathoms, active hydranths of this species have been dredged by us in July and August. Certain others among our local hydroids are likewise known to be dormant, or at least less active during the summer months. It is quite conceivable that at somewhat higher temperatures such species would be destroyed altogether.

We may say, then, that while there is some evidence for the operation of the principle of Merriam, in both of its phases, in determining the distribution of marine organisms in local waters, it seems likely that no single formula will suffice to explain all the phenomena involved;[a] and it is certain that we can form no adequate explanation of these until vastly more data are at hand. Both observation and experiment are demanded.

4. THE INFLUENCE OF DEPTH.

The great majority of species which were dredged by us in Vineyard Sound and Buzzards Bay were found to have a distribution, in local waters, which plainly bore no relation to depth. There are notable exceptions to this statement, however, some of which it is our purpose to discuss in the present section.

Leaving out of account the multitude of strictly "littoral" or intertidal forms, we meet with a considerable number of species which are limited to comparatively shallow waters. An analysis or the depth records for all these species[b] reveals the occurrence of many which were taken by us nearly or quite exclusively in waters less than 10 fathoms deep. Many of these species, indeed, occur wholly or predominantly at depths of less than 5 fathoms. A considerable number of such instances have been mentioned in the discussions for the separate subdivisions of the animal kingdom. A few of the commoner species, among those dredged, which show a distinct preference for the shallower waters, both in the Bay and the Sound, are: *Pista palmata*, *P. intermedia*, *Amphithoë rubricata*, *Bittium nigrum*, *Cerithiopsis emersonii*, *Crepidula convexa*, *Lacuna puteola*, *Lyonsia hyalina*, and *Mya arenaria*. Now, an examination of the distribution charts for these species shows that they were dredged chiefly, if not wholly, near shore. Some of them, at least, are known to inhabit the intertidal zone as well. It is a noteworthy fact fact that in some cases these species were dredged by the *Fish Hawk*, as well as by the *Phalarope*, but only at such of the *Fish Hawk* stations as were situated in the neighborhood of land. The depth at these points was often considerable, however (10 to 15 fathoms). Facts of this nature point to the conclusion that *proximity to shore* rather than *depth*, as such, may be the factor concerned in determining the lower limit of distribution for species of this sort. Before deciding the point definitely, it would be necessary to determine whether these "adlittoral" species occurred likewise on shoals at considerable distances from the land. Unfortunately, we have no satisfactory data on this subject,

[a] Petersen (1893, p. 445), declares the view of Semper that "every single species is affected by the temperature in a way characteristic to itself alone is, I think, in the highest degree applicable to our marine animals."

[b] Tables presenting these data were prepared for use in the preparation of this report, but they have not been included herewith.

since the only shoal so situated (the Middle Ground), lying within the territory dredged by us, is made up to a considerable degree of shifting sand, ill adapted to the support of most animal life.

It may be well at this point to recall the type of distribution displayed by many species whose occurrence is general in Vineyard Sound, but which in Buzzards Bay are limited to the immediate vicinity of shore. If we had the data for the Bay alone at our disposal, it would be natural to suppose that the species had a definite bathymetric limit. We have, however, the best reasons for believing that it is the muddy character of the bottom, throughout the deeper parts of the Bay, which restricts the distribution of such forms.

Whatever be the causes which are responsible for limiting certain species to the shallower waters skirting the shore, it is certainly desirable that we should have a suitable word by which to designate both the fauna inhabiting these waters and the habitat which they occupy. For this purpose we have already employed at various times the term "adlittoral," which, so far as we know, has not been used by previous writers. Were there any unanimity, even among zoologists, in the use of the word "littoral" itself we should have no hesitation in recommending this term adlittoral. But the former word has been applied with very different degrees of inclusiveness, having been restricted by some to the intertidal zone; while by others it has been so extended as to take in the whole continental shelf.[a] It is in the more restricted sense that the term has been employed in the present report. For this, the word "tidal"[b] would be unequivocal and, indeed, self-explanatory. But, unfortunately, we could not well speak of a "tidal species," however appropriate the expression "tidal zone" would seem. Again, this word does not lend itself readily to a combination with Latin prefixes such as "sub" and "ad."

Now the word "sublittoral" has likewise been used with very varying inclusiveness,[c] from "just below the shore line" (Standard Dictionary) to a zone reaching to the greatest depths at which algæ flourish (Kjellman).[d] This latitude of definition rests upon the inherent ambiguity of the word itself. For there is nothing in its composition to imply a limit of depth, any more than there is in the words "submarine" or "subterranean."

It is therefore with hesitation that we have chosen the term "adlittoral" as designating the zone of shallow water immediately adjacent to the shore. We have not, it is true, set any definite lower limit of depth to this zone. That would doubtless vary with different species; likewise with the abruptness of descent of the sea floor.[e] But even in this loose and inexact sense it is certainly a convenient term by which to designate such waters as those dredged by us with the *Phalarope* and *Blue Wing*. As a useful alternative term "infratidal" might be employed, though there is no implication in this word of a lower limit of depth any more than in "sublittoral."

A converse type of distribution to that just discussed is exhibited by certain other forms which were dredged predominantly at depths of 10 fathoms or more. A few of the commoner of such species are: *Tubularia couthouyi*, *Strongylocentrotus droebachi-*

[a] E. g., by Petersen and by Ortmann. The littoral zone of Edward Forbes, on the other hand, extended from high-water mark to a depth of 2 fathoms. To make confusion worse confounded, we have the "littoral" fauna and flora of land zoology and botany, which are not marine at all.

[b] The substitution of this term is favored by Dr. Stejneger in a letter to one of the authors.

[c] A circular letter of inquiry which we sent to eight leading American ecologists revealed a surprising lack of unanimity in the use of all these terms.

[d] It is in this latter sense that the term is employed in the botanical section of this report (cf. p. 453, 454).

[e] Perhaps it would ordinarily be limited, in Buzzards Bay and Vineyard Sound, by the 5-fathom line, but this would not always be true.

ensis, *Cancer borealis*, *Ovalipes ocellatus*, *Pagurus acadianus*, *Astarte castanea*, *Astarte undata*, *Venericardia borealis*, and *Amaroucium stellatum*. Now, a number of the foregoing species, and in general a considerable proportion of those species which are limited to the deeper waters, have already been mentioned among the northern forms whose distribution is determined locally by temperature conditions. It must be repeated, however (see p. 28), that the waters of the western end of Vineyard Sound are little if any deeper on the average than those in the vicinity of Nobska and West Chop. The preference of these species for deeper waters is shown by their scarcity in the adlittoral zone. Certain of them, indeed, were dredged only by the *Fish Hawk*. It is more than likely that the somewhat lower summer temperature of these bottom waters, as compared with those skirting the shore, is the factor responsible for the restriction of some species to the former. The temperature factor is not the one directly concerned, however, in the case of all of the animals named. The distribution of *Ovalipes*, for example, is probably wholly determined by the character of the bottom. It is indeed known to occur on sand flats in shallow, warm water. The case of *Amaroucium stellatum* is interesting, since, although a deep-water species in the sense here employed, it is for the most part restricted to the more easterly portions of the Sound, where the bottoms are gravelly or stony. Thus its preference for deeper waters does not appear to be related to the temperature factor, though this is not entirely certain, since the deeper waters are everywhere somewhat cooler in summer than are the shoaler ones. The marked restriction of this species to the former is in striking contrast to the condition shown by the related *Amaroucium pellucidum constellatum* (=*A. constellatum* Verrill), which, although associated with *A. stellatum* at various points, is likewise found in profusion in shallow waters and even upon piles.

The vertical distribution of marine organisms is commonly designated by the term "bathymetric," and it has been sometimes supposed that depth was one of the primary factors determining distribution. There are, of course, at least four factors bound up in this one, viz, pressure, temperature, light, and gas content. Now, it is not at all certain to what degree, if any, pressure influences distribution. For the limited depths within our region, we may certainly leave it out of account.

Temperature is, as we have seen, definitely correlated with depth in the sea, just as it is with altitude on land. But there is, in local waters, little difference between surface and bottom temperature, except in those portions of the Sound and the Bay which adjoin the open ocean. Some of the cold-water species inhabiting these last are, as just stated, restricted to the greater depths. On the other hand, the restriction of certain species (see above) to the shallow water immediately skirting the shore may be due in some cases to the palpably higher temperature commonly met with at such points during the summer.

The relation of light to depth has been treated at some length in the botanical section of this report (p. 447–449), to which the reader is referred. It is likely that for relatively slight depths, such as those we are considering, the light factor has little direct effect upon the bathymetric distribution of animals. Indirectly it may be of influence in the case of certain forms which dwell upon algæ, and it is possible that some of the adlittoral species which have been discussed above are limited in this way.

It may be repeated in conclusion, however, that, as regards the species taken during our dredging operations, the great majority show little or no evidence of bathymetric distribution.

5. POSITION OF THE LOCAL FAUNA IN ZOOGEOGRAPHY.

Certain questions will naturally present themselves to the student of geographical distribution: What is the position of the Woods Hole fauna in the fauna of our American coast? To which of the larger zoogeographical regions does it belong? And is it situated in the middle of that region or close to one of its limits? In other words, do the majority of species have a range which extends mainly to the northward along this coast, or do the majority have, on the whole, a southward range; or is there no apprecible preponderance of one sort over the other? Simple as these questions may seem, it is difficult to give them an answer that is at all satisfactory. The known range, as distinguished from the actual range, of a species, is very frequently determined by historical accident. Thus the Bay of Fundy, Massachusetts Bay, Woods Hole, Newport, New Haven, Charleston, etc., frequently figure in our literature as limits of distribution, and this for reasons which are obvious to anyone familiar with the history of American marine zoology. Verrill and Smith, in their Vineyard Sound report, give Cape Cod as the southern limit, or the northern limit, of distribution for many species whose known range has since been extended far beyond this point.

Likewise the impossibility must be borne in mind of forming a just estimate of the geographical range of a species from any mere statement, however correct in itself, of the extreme limits of its distribution. The bathymetric range and other factors of its habitat at various latidudes must be taken into consideration. It was long ago pointed out by Edward Forbes (1844, p. 323) that "parallels in depth are equivalent to parallels in latitude." Walther (1894) states that from the surface down the temperature declines about 1° C. for each 18 meters. Accordingly, a species which is truly "boreal" in its general tendencies, and which occurs in abundance along the littoral zone, in northern latitudes, may none the less be found in the deeper colder waters of a region far to the southward. To state such a range merely in terms of latitude would be highly misleading. Again, it is obvious that the same importance must not be attributed to the isolated and occasional occurrence of a given species as to its occurrence at points where it is widespread and abundant. But in many of the tables which are available for consultation no distinction is made between the two.

Furthermore, the question as to the position of the Woods Hole fauna, from the standpoint of zoogeography, can not be answered until we have made clear what is to be understood by the "Woods Hole fauna." If by this expression we are to mean the aggregate number of species which have ever been taken within the limits adopted, the question would be a difficult one to answer, and the answer, when given, would be of little value. Such an inclusive list (which would be coextensive with our own annotated list or catalogue) would comprise not only the truly indigenous species, characteristic of the region, but the occasional stragglers borne from southern waters by the Gulf Stream, and likewise those northern forms which we have met with only at Crab Ledge or in the colder waters off Gay Head. These are mostly rare species locally, and are in no sense characteristic of the shallower waters of this section of the New England coast, yet the total number of such species is very considerable. In practice, however, it is difficult to separate the truly indigenous types from those which are to be regarded as exotics or stragglers. An arbitrary basis of selection must therefore be adopted. For the purposes of the ensuing analysis we have included as representative local species only those which have been taken at 10 or more of the dredging stations. There are

thus eliminated a large number of forms which are relatively uncommon in these waters. The remaining ones, on the other hand, being, for the most part, of comparatively common occurrence, are just those whose general range of distribution is probably known with the greatest accuracy. Such a list, of course, comprises only bottom-dwelling organisms which occur at depths sufficiently great to be taken by the dredge. It consequently excludes the littoral and pelagic life as a whole, and therefore does not represent every element of the fauna.

Before entering upon such an analysis, however, it may be of interest to consider some of the prevalent opinions regarding the distribution of marine animals and plants upon this section of the coast.

It has been pretty generally assumed that Cape Cod forms a rather definite boundary between the fauna and flora inhabiting the regions above and below it. This was urged by Gould as early as 1840 (see Gould, 1840, p. 491), as the result of a study of the distribution of marine mollusks. Gould asserts that "many whole genera do not pass from one side to the other of this limit. Of the 203 marine species, 81 do not pass to the south and 30 have not been found to the north of the Cape, though many of them approach within a very few miles of each other." It was the opinion of Dana, likewise (1852, 1853), that there occurred at Cape Cod "a remarkable transition in species, and a natural boundary between the south and the north." Dana recognized four zoogeographical divisions of the Atlantic coast of North America, viz, the Acadian (first called by him "Nova Scotian"), Virginian, Carolinian, and Floridan. Cape Cod, he believed, served to divide the Acadian, lying to its north, from the Virginian on the south. Packard sought to distinguish another region, the "Syrtesian," on the north of the Acadian, between the latter and the arctic or polar.[a]

From a consideration of the actinians and echinoderms, in particular, Verrill (1866) was led to the belief "that there are portions of three distinct Faunæ to be distinguished on the coast of New England, viz: First, that known as the Virginian Fauna, extending from Cape Hatteras to the southern side of Cape Cod. * * * Second, that known as the Acadian or Nova Scotian Fauna, which extends along the shore from Cape Cod to the mouth of the St. Lawrence River, and includes * * * and many of the banks to the southward of Cape Cod, such as Nantucket Shoals; and perhaps the extreme end of Long Island. * * * Off the coast of New Jersey, also, there are deep-lying banks or shoals, which may be referred to this Fauna. * * * Third, a more arctic Fauna characterizes the eastern coast of Labrador and Newfoundland, and the Grand Banks, which extends far southward along our coast in deep water, influenced by the polar current of cold water[b] which skirts the northern part of our coast." This is the "Syrtesian" fauna of Packard.

Later (1871), referring especially to his dredging operations in Vineyard Sound and vicinity, Verrill writes: "One of the most important of the results of these investigations * * * is that while the shores and shallow waters of the bays and sounds, as far as Cape Cod, are occupied chiefly by southern forms, or the Virginian fauna,[c] the deeper channels and the central parts of Long Island Sound, as far as Stonington, Conn., are inhabited almost exclusively by northern forms, or an extension of the Acadian Fauna."

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[a] Gill, 1873, p. 782, likewise recognizes the Arctic, Syrtesian, Acadian, Virginian, and Carolinian faunas.

[b] Concerning the probability of the existence of such a current, see Chapter II of the present report.

[c] Perkins, on the other hand, from a consideration of the mollusks of the vicinity of New Haven, wrote in 1869: "The fauna of the region belongs about equally to the Acadian and Virginian faunæ.

S. I. Smith (1879), likewise, from a study of certain groups of Crustacea, was led to believe that "the fauna from Cape Cod to Labrador is essentially a continuous one, or at least that there are no changes in it comparable with the differences between the fauna south and that north of Cape Cod Bay."

By the botanists, also, an equally great importance has been attributed to Cape Cod as a division between the floral regions distinguished by them. Harvey (1852) recognized one region north of Cape Cod, "extending probably to Greenland," while his second region extended from Cape Cod to the southward as far as Cape Hatteras.

Farlow wrote in 1882:

> It will be seen that Cape Cod is the dividing line between a marked northern and southern flora. In fact the difference between the floræ of Massachusetts Bay and Buzzards Bay, which are only a few miles apart, is greater than the difference between those of Massachusetts Bay and the Bay of Fundy or between those of Nantucket and Norfolk.

Somewhat earlier (1873), in answer to the question "whether northern species do not occur at exposed southern points, as Gay Head and Montauk, and southern species wander northward to Cape Ann," he gave the answer: "Most decidedly, I think, such is not the case." Such an extreme position as this has not, however, been taken by the author of the botanical section of the present report.

It would be futile, on the basis of our own researches into the fauna of the Woods Hole region, to enter into any extended discussion regarding the position of this region upon the zoogeographical map of the world.[a] As an adequate preliminary to such a discussion one would need to have a more or less intimate knowledge of the fauna of both shores of the Atlantic from the Arctic Ocean to the Tropics.

In a table in chapter III (p. 88, 89) we have indicated the number of species, representing each of the chief subdivisions of the animal kingdom, which have been recorded from the Woods Hole region and from several other localities where a careful inventory of the fauna has been made. The number of species has been stated, also, which are known to be common to Woods Hole and to eastern Canada, and the number common to Woods Hole and to Plymouth. It will be found that 365(+4?) species are common to the Woods Hole and the Canadian lists. This number represents more than 30 per cent of the total number of determined Woods Hole species belonging to groups which were considered in making the Canadian list (i. e., omitting vertebrates and parasitic worms). On the other hand, only 15 per cent of the determined Woods Hole species (belonging to groups for which a comparison is possible) are common to the Plymouth list. A critical comparison of American and European species, and particularly an exhaustive search of the synonymy, would probably increase the latter figure somewhat.

It is much to be regretted that no list has been prepared with similar care of the fauna of some region lying about as far to the south of Woods Hole as the Gulf of St. Lawrence lies to the north. It might be confidently predicted that the percentage of our local species which would appear in such a list would be very greatly in excess of the 30 per cent which are common to Canada. Data bearing upon this phase of the subject will, however, be introduced presently.

One might perhaps have expected to find a much larger proportion of our Woods Hole species in the vicinity of Plymouth than the 15 per cent which have been recorded. To what degree these differences in fauna are due to differences in physical conditions

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[a] We fear that much ingenuity has been wasted in the past in an endeavor to distinguish all the various "faunas" represented on a single section of our coast. Such entities are, after all, to a large extent figments of the imagination.

and to what degree they are due to geographical isolation we can not say. The surface temperature of the sea in the neighborhood of Plymouth is said to range from about 44° F. (February) to about 59° F. (August). (See Dickson, 1892, p. 276.) In this respect the conditions are far different from those in Vineyard Sound, in which the annual range of temperature is roughly from 30° F., or less, to 70°. On the other hand, we know that broad expanses of ocean are effective barriers to distribution, even for marine organisms.

Although we have not undertaken the ambitious task of making extended comparisons between the Woods Hole fauna and the faunas of other sections of the Atlantic coast, we have nevertheless been able to give some answer to the questions: (1) Have the majority of our more representative species a range which is predominantly northward or one which is predominantly southward? (2) In how large a degree is Cape Cod a barrier to distribution?

As stated above, we have considered for this purpose only those species which have been taken at 10 or more of our dredging stations, and which, therefore, may be regarded as those which are most truly representative of our local benthos. Of such species there are 202, excluding 9 species of Protozoa. In the various sections of chapter IV these species have been grouped according to their range upon our coast, and a synopsis of these separate lists is presented in a table herewith. It may be repeated that a species has been regarded as predominantly northward-ranging, whose range (in latitude) to the northward on our coast is at least twice as great as its range to the southward.[a] A species has been regarded as southward-ranging which presents the converse type of distribution. The column headed "Equal" refers to those species whose known range in one direction does not greatly exceed the known range in the other direction; while the doubtful column includes those concerning which our data are insufficient. In many cases they have been found only in the immediate vicinity of Woods Hole.

	Predominantly northern.	Predominantly southern.	Equal.	Doubtful.	Total.	Known to occur north of Cape Cod.	Known to occur south of Woods Hole region.[b]
Sponges	1	1	1	....	3	2	2
Cœlenterates	6	3	2	2	13	11	9
Bryozoa	4	4	7	6	21	12	11
Echinoderms	3	2	....	2	7	6	7
Annulata	5	22	2	1	30	13	27
Sipunculida	....	....	1	....	1	1	1
Cirripedia	....	1	....	....	1	1	1
Amphipods	7	5	....	7	19	8	6
Isopods	....	2	1	....	3	1	3
Decapods	2	8	3	....	13	8	13
Pycnogonids	....	1	....	1	2	1	1
Mollusks	16	43	8	1	68	50	67
Tunicates	....	4	....	4	8	3	5
Fishes	2	5	6	....	13	13	12
Total	46	101	31	24	202	130	165

[a] This criterion has not been applied to those cases in which it is definitely known that the extreme southern records relate only to great depths.

[b] Long Island Sound has not been regarded as south of the Woods Hole region. Had it been so considered, the figures in this column would have been materially increased.

Of the entire 202 species, 101, or exactly 50 per cent, are believed to have a range upon our coast which is predominantly southward; 46 species (23 per cent) have a range which is predominantly northward; while 31 of them (15 per cent) have a range of approximately equal extent, so far as known, in both directions. The remaining 24 species have been relegated to the doubtful column. The fact to be emphasized is that the ratio of southward-ranging species (as thus defined) to northward-ranging species is greater than two to one, while about 15 per cent of them do not seem to be thus restricted in latitude.[a]

Viewing these 202 species in another way, it is to be noted that 130, or about 64 per cent of them, are known to have a range extending north of Cape Cod, leaving 72 of them (36 per cent) which, so far as reported, have not transcended this barrier. Doubtless more complete information will reduce the latter figure. As has already been pointed out, any locality where extensive collecting has been done is sure to figure as the reputed limit of distribution, whether northern or southern, for many species. It is significant, therefore, that only 37 of the species under consideration (18 per cent) have not yet been recorded from points south of Woods Hole.[b] Comparing this figure with the 36 per cent which are not known to occur north of Cape Cod, it may be that we have some measure of the real effectiveness of the last as a barrier to distribution.

Crude, in the extreme, as any such computations must be, the conclusions seem to be fairly well grounded (1) that Cape Cod does have an appreciable influence as a barrier to distribution, and (2) that the southern types preponderate considerably over the northern ones in our Woods Hole fauna, or at least in that part of it which is accessible to the dredge. These generalizations may not be true of each individual group (e. g., cœlenterates and amphipods); and in general it must be remembered that a considerable minority of northern forms are included in our local fauna, while about 64 per cent of our species are known to occur north of Cape Cod. On the other hand, it is well to state that our local fish fauna, which is but sparingly represented in our dredging records, and consequently plays little part in the foregoing tabulation, is overwhelmingly southern, 75 per cent being southward-ranging in the foregoing sense of the term, while nearly 50 per cent of the total number of recorded species are such as are reputed to find in Cape Cod their northern limit of distribution. And, lastly, we must bear in mind that we are here dealing only with the benthos of the region, the plankton, as well as the littoral fauna, being left out of consideration.

6. COMPARATIVE DISTRIBUTIONS OF CLOSELY RELATED SPECIES.

Turning to another phase of our subject, it would be unreasonable to look to the results of such a survey as the present one for any considerable light upon the origin of species. Those who insist upon the importance of isolation as a factor in species differentiation are wont to maintain that different subspecies do not coincide in their ranges, but that these supposedly incipient species are practically always separated from one another, geographically or otherwise. After the complete splitting of a species, i. e., its replacement by several specifically distinct forms, these latter may by migration, it is said, come to occupy the same territory.

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[a] The similar treatment by Hoyle of the deep-water fauna of the Clyde sea-area was unknown to the present writers at the time when the foregoing discussion was written. (See Hoyle, 1890, p. 463 et seq.).

[b] More strictly, south of Vineyard Sound and Buzzards Bay. Block Island and Long Island Sound have not been regarded as farther south.

Jordan, who is one of the foremost recent advocates of the theory of evolution by isolation, tells us (1905) that "it is extremely rare to find two subspecies inhabiting or breeding in exactly the same region." Again: "Given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort" (p. 547). This, he says, "may be raised to the dignity of a general law of distribution."

Few groups of marine animals have been worked as intensively as have the birds and fresh-water fishes upon which Jordan chiefly relies for evidence in favor of his theory. It is largely due to this fact, probably, that "subspecies," "varieties," and "geographical races" play a relatively minor part in the taxonomy of marine animals. We thus have practically no data at our present disposal to test the first of Jordan's assertions quoted above. A case which perhaps deserves mention at this point, though its relevance may well be questioned, is that of the mollusk *Polynices heros*, and its supposed variety, *triseriata*. We must make the reservation at once that these are regarded by some conchologists, e. g., Dall, as distinct species, and in fact we have ourselves followed Dall in so listing them in our catalogue.[a] A glance at the charts[b] (187,188) reveals the fact that while the two forms coexist throughout much of their range, they nevertheless do not present the same distribution patterns, but appear to show distinct preferences as to habitat. There is, however, no real *geographical* isolation, for the two forms occur on closely adjacent parts of the sea floor, being taken together, not infrequently, in a single dredge haul.[c] Whether or not these two species (or varieties?) cross freely, and with what results, we have no means of knowing at present.

It is impossible, likewise, for us to state whether or not the species *nearest related* to any given one among our local fauna occurs in this region, or in a "neighboring district." Such a question could be answered only after an exhaustive research into the fauna of neighboring parts of our coast. We have a considerable collection of data, however, with which to answer the kindred questions: (1) To what extent do members of the same genus tend to differ in habitat? and (2) Are different members of the same genus less likely to be associated together than species not so closely related?

As bearing upon the first of these questions, the comparative distributions of different species of the same genus have been presented by us in a large number of cases. The reader is especially referred to the following examples:

Eudendrium, 2 species (charts 16, 17).
Tubularia, 2 species (charts 18, 19).
Asterias, 2 species (charts 48, 49).
Nephthys, 2 species (charts 57, 58).
Ampelisca, 2 species (charts 87, 88).
Pagurus, 4 species (charts 109–112).
Cancer, 2 species (charts 115, 116).
Anomia, 2 species (charts 123, 124).
Pecten, 2 species (charts 125, 126).
Arca, 3 species (charts 131–133).
Astarte, 2 species (charts 138, 139).
Busycon, 2 species (charts 164, 165).
Crepidula, 3 species (charts 183–185).
Polynices, 3 species (charts 186–188).
Amaroucium, 3 species[d] (charts 195–197).

[a] In any case the relationship will be conceded as being very close.

[b] Only the occurrence of living specimens (designated by circles) can be taken into account here, since the dead shells are probably transported considerable distances by hermit crabs.

[c] As regards geographical range, that of *Polynices heros* is stated by Dall as extending from Labrador to Virginia; that of *triseriata* being practically identical, i. e., from Labrador to Cape Hatteras.

[d] In our catalogue we have followed Dr. Van Name in not regarding one of these as a distinct species.

There are several ways in which two species may differ in respect to their distribution patterns: (1) The species may occur throughout practically the same area, differing only in their relative abundance; (2) the range of one may be restricted to a portion of the area occupied by another; (3) they may have distributions which are in a certain degree complementary to one another.

Referring to the genera named, it will be found that in few cases, if any, are the distributions of two members of the same genus practically identical, both as regards the area inhabited and the frequency of occurrence. In a number of instances, however, they differ only in respect to frequency.

The type of difference most often realized upon our charts is the second among those mentioned above. In such cases one species may occur throughout only a portion of the territory occupied by the other; or, at least, it may not be well established except in this portion.

The third condition—that of two species of the same genus having distribution patterns which are complementary to one another—is realized in a surprisingly small number of cases upon our charts. It appears most clearly from a comparison of the distributions of *Pagurus acadianus* (chart 110) and *P. annulipes* (chart 112). We have seen that these are respectively northward-ranging and southward-ranging species; so that the habitat selected by each in local waters is not improbably determined by temperature.

It is a familiar fact to field naturalists that the various members of the same genus frequently, if not generally, occupy somewhat different habitats. Obvious instances of this are not uncommon among our local littoral and shallow-water fauna, as for example the three familiar species of the genus *Littorina*. Now, our dredging charts are not adapted to revealing such slight differences of habitat as may occur within the limits of a single "station." In the charts for *Crepidula*, for example, there is nothing to show that *C. fornicata* does not coincide in its habitat as well as its distribution, with *C. plana*; whereas we know that, in most cases, the latter occupies the inside of a hermit-crab shell, while the former may occupy the outside of the same shell, or may adhere to any solid object whatever. It is probable, likewise, that the drifting of shells and other lifeless remains may result in an apparent obliteration of actual distinctions in the distribution of species. Finally, it seems needless to remark that in no single case is the entire range of a species indicated upon one of our charts. Thus, even in cases where two species appear to coincide in their distribution locally, the range of one may extend into far deeper water, off the coast, than that of the other. It seems to us, therefore, that the differences in the distribution of closely related species have been minimized, rather than exaggerated, in our graphic representations.

Whether or not specific differentiation preceded or followed these changes of habitat, or whether they went on *pari passu* with such changes, is not even suggested by any of the facts which we have encountered. Who can say, for example, whether the tendency to restrict itself to muddy bottoms preceded or followed the differentiation of the amphipod *Ampelisca macrocephala* as a species distinct from *A. spinipes*? Nevertheless, the bare fact that various closely related species do show decidedly different distribution patterns is one of great interest, for it shows that the slight morphological differences by which the species are distinguished from one another are oftentimes

correlated, with marked physiological differences sufficient to adapt the two to differing habitats. Thus the assertion so often made that the slight structural differences by which we distinguish one species from another are commonly of no conceivable utility, and therefore can never have arisen through the action of natural selection, loses much of its force. While it may be true that these slight structural differences in themselves can play no significant rôle in the life of the organisms concerned, it is likewise evident that there are certain correlative physiological changes sufficient to adapt the organisms to somewhat different modes of existence. That natural selection has been the controlling factor in the origination and perpetuation of such specific differences, whether morphological or physiological, is far from certain. But that the characters concerned are in most cases too insignificant to be of selective value is also far from certain.

Where we have to do merely with the adoption of a more restricted habitat by one species than by another, it is quite possible that the physiological difference in question relates merely to general constitutional vigor; i. e., the less hardy species may restrict itself to the more favorable portion of the habitat.[a] Where, however, the ranges of the two species are more or less complementary to one another, particularly if they do not coincide throughout any portion of their extent, such an explanation is of course out of question, and we are obliged to fall back upon the assumption that each is more or less specifically adapted to its respective habitat.

In order to throw light upon the second of the above questions (i. e., Are members of the same genus less likely to be associated together than species which are not so closely related?), we have adopted a method employed by Herdman (1895). This author, after noting the relatively large number of genera represented by the species taken in a single dredge haul,[b] writes: "These figures are particularly interesting in their bearing on the Darwinian principle that an aminal's most potent enemies are its own close allies. Is it then the case, as the above cited instances suggest, that the species of a genus rarely live together; that if in a haul you get half a dozen species of lamellibranchs, amphipods, or annelids they will probably belong to as many genera, and if these genera contain other British species these will probably occur in some other locality, perhaps on a different bottom, or at another depth? It is obviously necessary to count the total number of genera and species of the groups in the local fauna, as known, and compare these with the numbers obtained in particular hauls." In Liverpool Bay, for example, "the known number of species of higher Crustacea is 90, and these fall into 60 genera. So the genera are to the species as 2 to 3," whereas in certain dredging collections cited "the genera are to the species on the average about as 28 to 31, or nearly 7 to 8. Again, the total number of species of Tunicata is 46, and these are referred to 20 genera; while in the case given above * * * the 12 species taken on one spot represented 10 genera, or a little over a quarter of the species represented half the genera. These, and many other cases which we might quote, seem to show that a disproportionately large number of genera is represented by the assemblage of species at one spot, which means that closely related species are, as a rule, not found together" (p. 463).

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[a] This suggestion has been made to us by Prof. Herdman.

[b] This fact was pointed out by Sir John Murray (Challenger "Summary," p. 1435), who, however, restricts its application to great depths, concluding "in the deepest zone, therefore, the species stand to the genera in the ratio of 5 to 4, and in the shallowest zone nearly as 3 to 1."

When subjected to statistical analysis, our results are in full agreement with those of Herdman, though we are not convinced of the truth of his interpretation.

As shown in the table on page 77, the average number of species per dredge haul, as based upon the 458 regular stations of the Survey, is 37.0, while the average number of genera per dredge haul is 34.3. Thus the average number of species per genus is approximately 1.08,[a] or the ratio of species to genera is about 13 to 12. This ratio we have thought best to compare, not with that derived from a consideration of the entire array of species and genera for the Woods Hole Region, but with that based upon the total number of species and genera, so far as encountered by us in the dredge. Among these are included 510 determined species, representing 361 genera. The average number of species per genus is thus approximately 1.41, or the ratio of species to genera is as 7 to 5.

So far, then, we seem to be in complete agreement with Herdman. A quite different explanation from that given by him has, however, suggested itself. It has occurred to us that the same relations would follow if some of our genera contained a considerable number of uncommon species. These latter might not be taken with sufficient frequency to affect appreciably the average number of species per dredge haul, but they would greatly augment the number of species per genus when the total number of those encountered were taken into account. Now, as a matter of fact, many of the genera do contain a considerable number of rare species—species which were taken once only, or a very few times—in addition to common ones. On the other hand, it is true that we also meet with certain rare species which are the only representatives in local waters of their respective genera. Thus there would seem to be nothing to show whether the inclusion of these less common species would augment or decrease the average number of species per genus in our fauna.

One test may be applied, however. We may restrict our computation to the *commoner* species, and determine the ratio of species to genera among these. For this purpose let us employ those species which were taken at 10 or more of our dredging stations. Among these we find 209 species[b] representing 178 genera. The average number of species per genus is thus about 1.18, a figure very much smaller than that representing the number of species per genus in the entire array of organisms dredged by us. Indeed it approaches more nearly the figure (1.08) expressing the average ratio within the limits of a single dredge haul. Thus the conclusion seems warranted that the larger number of species per genus found to occur in the fauna at large, as compared with the average number for a single dredge haul, is due largely, if not wholly, to the inclusion in the former reckoning of the rarer members of certain genera. Such species do not, on the other hand, occur with sufficient frequency to appreciably affect the ratio for the average dredge haul. If this reasoning be correct, what seemed to be a fascinating and clear-cut demonstration of a significant principle of distribution falls to the ground.

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[a] We are quite aware that the ratio between these gross averages has not exactly the same value as the average of the separate ratios for the various dredge hauls. In other words, $\frac{a+b+c}{3} \div \frac{x+y+z}{3}$ has not the same value as $\left(\frac{a}{x}+\frac{b}{y}+\frac{c}{z}\right) \div 3$. Where the number of terms is so great, however, the results derived from the two methods of computation must be sufficiently close for present purposes.

[b] Including Protozoa.

7. CHANGES IN THE COMPOSITION OF THE LOCAL FAUNA.

Every area of land or sea doubtless undergoes more or less frequent changes in the composition of its fauna and flora, due to the immigration or artificial introduction of exotic species or the extinction of indigenous ones. For the Woods Hole region we have certain well-known and highly authentic instances of this phenomenon, together with some others which seem probable, if only inferential.

The best-known local instances of the sort are those of the European periwinkle, *Littorina litorea*, and of the small sea anemone, *Sagartia luciæ*. Rather full accounts of the history of both of these immigrants are fortunately extant. (See Verrill, 1880; Ganong, 1886; Verrill, 1898; Parker, 1902. These accounts are summarized in our own catalogue.) It may be here remarked that the periwinkle reached Woods Hole from the north about 1876; while the anemone seems to have come from the south, arriving about 1898. Within about 30 years, and perhaps much less, *Littorina litorea* has become the most abundant and generally distributed of our littoral (intertidal) mollusks, while *Sagartia luciæ* in a considerably shorter time has become by far the commonest local actinian. It would be interesting to know what effects, if any, these immigrants have had in limiting the abundance or restricting the distribution of species already present. Unfortunately few observations, if any, have been made to test this point.

Concerning certain other species, we have some reasons for believing either that they are, in local waters, far more abundant now than formerly, or that they have actually migrated hither within recent years. The only other alternative seems to be that they were overlooked or confused with quite distinct species by a number of competent naturalists. For example, of our four local species of hermit crabs, *Pagurus annulipes* is second in abundance only to the ubiquitous *P. longicarpus*. Its distribution in local waters is almost universal, as will be seen from a glance at the distribution chart for this species. Yet this hermit crab was not mentioned by Verrill and Smith in 1873,[a] nor, so far as we are aware, has it been recorded for local waters in any work prior to Miss Rathbun's catalogue of the Crustacea of New England (1905). We have, it is true, learned from Miss Rathbun that specimens of this crustacean were recently found among the earlier material dredged by Verrill and Smith. But the fact that it was overlooked, or at least not mentioned by these writers, raises strong doubts as to whether it occurred then in its present abundance.

Another problematic case is that of one of the shore barnacles, *Chthamalus stellatus*,[b] which at present is extremely abundant upon stones and boulders between tides everywhere. This well-known European species is, in our waters, at least, quite distinct in appearance from the other common shore barnacle (*Balanus balanoides*). Yet it has not been mentioned in any catalogue of New England fauna, although several far less common cirripedes have been listed. It is hard to believe that this species has been habitually confused with *Balanus balanoides* by the long succession of field naturalists and systematic zoologists who have exploited the shores of New England for

[a] Allowance must be made for the fact that, in the words of one familiar with the circumstances, "the Vineyard Sound report was prepared when the Fish Commission had spent but one summer at Woods Hole, and was rushed through expeditiously for insertion in the Fish Commission Report for 1871–72. It did not list everything that had been discovered, but omitted much that had not been sufficiently studied."

[b] For an account of this case, see Sumner, 1909.

over a century.[a] These men erred rather in the direction of discovering too many new species than in ignoring well-established ones.

The medusa, *Gonionemus murbachii*, does not seem to have been observed until 1894, when according to Perkins (1902) it "made an astonishingly sudden appearance upon the scene." Yet at present this relatively conspicuous and readily recognizable medusa is one of the most familiar objects of research in the Woods Hole laboratories. Its distribution, locally, appears to be rather restricted, however, most of the collecting for this species being carried on in one small salt-water pond.

The large noncolonial hydroid, *Tubularia couthouyi*, whose conspicuous yellow perisarcs are dredged with considerable frequency in Vineyard Sound, was likewise not referred to in the report of Verrill and Smith, although this latter listed a number of other hydroids which have not been noted by any subsequent observers. And it is likewise somewhat astonishing that neither of our local species of *Arenicola* was mentioned in the Vineyard Sound report, although one, at least, of these immense annelids is now common at points in the vicinity of Woods Hole.

We can not attribute so much importance to the failure of previous writers to record the gastropod *Lacuna puteola*, since this species, although very abundant, is likewise very small. The same may be said of a considerable number of other species which are comprised in our list but were not recorded by various previous observers. Inconspicuous or uncommon species may readily be overlooked, even by competent collectors. Such an oversight seems unlikely, however, in the case of the other examples cited above.

Just the opposite state of affairs is to be noted in the case of certain species which were recorded by Verrill as common in local waters, but which the present writers have seldom or never met with. As a striking instance of this is to be mentioned the anemone *Edwardsia lineata* Verrill, concerning which the last-named zoologist makes the following entry (p. 739): "Vineyard Sound and off Gay Head, 6 to 12 fathoms, among ascidians, annelid tubes, etc., abundant." A search in just such situations, both by Prof. Hargitt and by ourselves, has failed to disclose a single specimen. The size, as stated by Verrill (25–35 mm. long), makes it unlikely that the species has been persistently overlooked by us.

The barnacle *Balanus crenatus* was recorded by Verrill and Smith as "dredged abundantly in Vineyard Sound." While we have found it to be common upon piles at Vineyard Haven, we have never, with a few possible exceptions, encountered this species with the dredge, either in Vineyard Sound or Buzzards Bay. This is true despite the fact that practically all of the barnacles dredged by us were saved for subsequent inspection.

The crabs *Libinia dubia* and *Panopeus* [*Eurypanopeus*] *depressus* are of far less general occurrence in these waters than the statements of Verrill and Smith seem to imply. Although we have encountered both of these species in the shallow waters near shore, we have not a single authentic record of either species having been taken in the dredge during the course of our operations.

While it is not likely that all of these discrepancies between earlier and later statements can be attributed to actual changes in the occurrence of species, it is probable that some of them are due to such changes.

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[a] It has just been learned from Prof. M. A. Bigelow that he noted the occurrence of this barnacle at Woods Hole in 1898.

8. CONCLUSION.

To the reader who would demand an exact economic equivalent for the labor and money here expended, our answer must be a very general one. Science and industry move together. Industry is helpless without the aid of science, and the greatest industrial progress is at present being made by those countries which realize this fact most fully. But science can never prosper if forced to play the rôle of a servant. She must be free to pursue her own ends without being halted at every step by the challenge: *Cui bono?* The attempt to restrict our scientific experts to problems of obvious economic importance would be equivalent to depriving ourselves of their services altogether. It is to-day accepted as a commonplace that all the great discoveries of a practical nature have rested ultimately upon principles first brought to light by the seeker after truth. The enlightened manufacturer of Germany looks upon a well-paid scientific investigator as a good invesment. As a result of this policy the rest of the world is looking on uneasily, while its own industries pass into the hands of this farsighted competitor. Great Britain and the Scandinavian countries, the great fishing nations of Europe, have long been leaders in the scientific investigation of the sea. And in recent years we have witnessed the formation of an international council, representing all of those nations having an immediate interest in the fisheries of the North Sea, and organized for the study of hydrographic and biological problems as well as of purely economic ones. To Americans there should be no novelty in all this. Let us keep in mind the oft-quoted words of the distinguished founder of our Fish Commission in outlining the policy adopted by him:

> As the history of the fishes themselves would not be complete without a thorough knowledge of their associates in the sea, especially such as prey upon them or in turn constitute their food, it was considered necessary to prosecute searching inquiries on these points, especially as one supposed cause of the diminution of the fishes was the alleged decrease or displacement of the objects upon which they subsist.
>
> Furthermore, it was thought likely that peculiarities in the temperature of the water at different depths, its chemical constitution, the percentage of carbonic-acid gas and of ordinary air, its currents, etc., might all bear an important part in the general sum of influences upon the fisheries; and the inquiry, therefore, ultimately resolved itself into an investigation of the chemical and physical character of the water, and of the natural history of its inhabitants, whether animal or vegetable. It was considered expedient to omit nothing, however trivial or obscure, that might tend to throw light upon the subject of inquiry, especially as without such exhaustive investigation it would be impossible to determine what were the agencies which exercised the predominant influences upon the economy of the fisheries.

So that if we can not, from our present labors, offer any suggestions of direct value to the practical fisherman, we trust that we have at least added to the intelligent understanding of the marine life of our coast. And we likewise trust that the *ultimate* benefit to the practical fisherman will be as great as that to the man of science.

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DESCRIPTION OF DREDGING STATIONS OCCUPIED DURING PRESENT SURVEY.

FISH HAWK STATIONS.

Station no.

7521. July 28, 1903. Nobska Light, NE, ½ mile; 10 fathoms; coarse sand; 24-inch rake dredge. (Dredge frame broken during haul.)

7522. July 28, 1903. Nobska Light, N ½ W, 1 mile; 10 fathoms; stony; 24-inch rake dredge.

7523. July 28, 1903. Nobska Light, NW by N ¾ N, 1⅝ miles; 13 fathoms; stony; 24-inch rake dredge. (Dredge net torn during haul.)

7524. July 28, 1903. Nobska Light, NNW ⅛ W, 2¼ miles; 10 fathoms; stony; 7-foot beam trawl.

7525. July 28, 1903. Nobska Light, NNW ¼ W, 2⅝ miles; 7 fathoms; sandy; 7-foot beam trawl.

7526. July 28, 1903. Nobska Light, N ¼ W, 2½ miles; 7½ fathoms; sandy; 7-foot beam trawl.

7527. July 31, 1903. West Chop SE by E, Tarpaulin Cove W by S ½ S; 9 fathoms; sand; 24-inch rake dredge.

7528. July 31, 1903. West Chop SE by E ¾ E, Nobska NE ¼ N; 13 fathoms; sandy; 24-inch rake dredge.

7529. July 31, 1903. West Chop ESE, Nobska NNE; 13 fathoms; sand and gravel; 24-inch rake dredge.

7530. July 31, 1903. Nobska N ½ E, West Chop E by S ¼ S; 12 fathoms; stony; 7-foot beam trawl.

7531. July 31, 1903. Tarpaulin Cove W ½ N, Nobska NE by N ¼ N; 8½ fathoms; sandy; 24-inch rake dredge.

7532. August 3, 1903. West Chop ESE, Tarpaulin Cove W by S ½ S; 10 fathoms; sand and stones 24-inch rake dredge.

7533. August 3, 1903. West Chop E by S ½ S, Tarpaulin Cove W by S; 10 fathoms; sandy; 24-inch rake dredge.

7534. August 3, 1903. West Chop E by S, Nobska Point NE, Tarpaulin Cove W ¼ S; 10¼ fathoms; stony; 24-inch rake dredge.

7535. August 3, 1903. Nobska Point N by E ¾ E, Tarpaulin Cove W by N; 10 fathoms; gravel and sand; 24-inch rake dredge (2 hauls).

7536. August 3, 1903. Nobska Point N by E ½ E, Tarpaulin Cove W by N ½ N; 5½ fathoms; sandy; 24-inch rake dredge.

7537. August 7, 1903. Tarpaulin Cove W by S ½ S, West Chop E by S ¼ S; 15 fathoms; coarse gravel; 24-inch dredge (2 hauls).

7538. August 7, 1903. Tarpaulin Cove W ¼ S, West Chop E ¾ S; 10 fathoms; stony; oyster dredge.

7539. August 7, 1903. Tarpaulin Cove W ¾ N, Nobska NE; 13 fathoms; stony; oyster dredge.

7540. August 7, 1903. Nobska NE ¾ N, Tarpaulin Cove W by N ½ N; 5 fathoms; sand and shells; oyster dredge and beam trawl.

7541. August 7, 1903. Nobska NE by N ½ N, Tarpaulin Cove WNW; 13 fathoms; sand and gravel; oyster dredge.

7542. August 7, 1903. Nobska NE by N ¾ N, Tarpaulin Cove NW by W ½ W; 7 fathoms; sandy; beam trawl.

7543. August 11, 1903. Gay Head SW ½ S, Nobska E by N ½ N; 12 fathoms; coarse gravel; oyster dredge.

7544. August 11, 1903. Tarpaulin Cove W ¾ N, Nobska NE by E ½ E; 10½ fathoms; coarse gravel; oyster dredge.

7545. August 11, 1903. Tarpaulin Cove WNW, Nobska NE ½ E; 10¼ fathoms; stones and coarse gravel; oyster dredge.

7546. August 11, 1903. Tarpaulin Cove NW by W ¼ W, Nobska NE ½ N; 5 fathoms; sand and stones; 7-foot beam trawl and 24-inch dredge.

Station no.

7547. August 11, 1903. Nobska NE by N, Tarpaulin Cove NW ¾W; 12 fathoms; stony; oyster dredge.

7548. August 11, 1903. Tarpaulin Cove NW ¼ W, Nobska NE by N; 6 fathoms; stony; 7-foot beam trawl.

7549. August 12, 1903. Tarpaulin Cove NW, Nobska ENE; 12 fathoms; stony; oyster dredge.

7550. August 12, 1903. Nobska NE by E ¼ E, Tarpaulin Cove NW ½ N; 12 fathoms; stony; 7-foot beam trawl.

7551. August 12, 1903. Nobska NE ½ E, Tarpaulin Cove NW ¾ N; 9 fathoms; sand; 7-foot beam trawl and 24-inch dredge.

7552. August 12, 1903. Nobska NE ¼ N, Tarpaulin Cove NW by N; 13 fathoms; sand and shells; oyster dredge.

7553. August 12, 1903. Nobska NE ¾ N, Tarpaulin Cove NW by N; 7¼ fathoms; sand and shells; 7-foot beam trawl.

7554. August 15, 1903. Nobska ENE, Gay Head SW ¾ S; 7½ fathoms; muddy; 7-foot beam trawl, oyster dredge, 24-inch dredge.

7555. August 15, 1903. Tarpaulin Cove N by E ¼ E, Nobska NE by E ¼ E; 12 fathoms; sandy; 7-foot beam trawl.

7556. August 15, 1903. Nobska NE ½ E, Tarpaulin Cove N; 9½ fathoms; sandy; 7-foot beam trawl.

7557. August 18, 1903. Tarpaulin Cove N by W, Gay Head SW ¾ W; 3½ to 10¼ fathoms; sandy; 7-foot beam trawl.

7558. August 18, 1903. Gay Head SW by W ½ W, Tarpaulin Cove N by W ¼ W; 17¼ fathoms; sand and shells; 7-foot beam trawl.

7559. August 18, 1903. Tarpaulin Cove N by W ½ W, Gay Head WSW; 5¼ fathoms; sandy; 7-foot beam trawl. (Very little material obtained.)

7560. August 18, 1903. Gay Head WSW, Tarpaulin Cove N ¼ W; 7 fathoms; sand and pebbles; beam trawl, and oyster dredge.

7561. August 18, 1903. Gay Head SW by W ¼ W, Tarpaulin Cove N ¼ E; 12½ fathoms; sand and stones; 7-foot beam trawl.

7562. August 18, 1903. Gay Head SW ½ W, Tarpaulin Cove N ¾ E; 5¼ fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7563. August 18, 1903. Gay Head SW, West Chop E by N; 8 fathoms; gravel; 7-foot beam trawl.

7564. August 18, 1903. Gay Head SW ¾ S, West Chop E ½ N; 13 fathoms; sand; 7-foot beam trawl.

7565. August 18, 1903. Gay Head SW by S ¼ S, West Chop E ¼ N; 15 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7566. August 21, 1903. Gay Head SSW, tangent Naushon E by N ¼ N; 7½ fathoms; sandy; oyster dredge. (Scanty haul.)

7567. August 21, 1903. Tarpaulin Cove NE ½ E, Gay Head SW by S ¼ S; 12 fathoms; sandy; 7-foot beam trawl and 24-inch dredge. (Scanty haul.)

7568. August 21, 1903. Tarpaulin Cove NE by N, Cedar Tree Neck E; 7¼ fathoms; sandy; 7-foot beam trawl and 24-inch dredge. (Scanty haul.)

7569. August 21, 1903. Tarpaulin Cove NE by N ¾ N, Gay Head SW; 7 fathoms; sandy; 7-foot beam trawl and 24-inch dredge. (Scanty haul.)

7570. August 21, 1903. Gay Head SW ¾ W, Tarpaulin Cove N by E ½ E; 12 fathoms; sandy; 7-foot beam trawl and 24-inch dredge. (Scanty haul.)

7571. August 21, 1903. Tarpaulin Cove N by E, Gay Head SW by W ½ W; 12 fathoms; muddy; 7-foot beam trawl and 24-inch dredge.

7572. August 21, 1903. Tarpaulin Cove N ½ E, Gay Head W by S ¾ S; 10 fathoms; sandy and stony; 7-foot beam trawl and 24-inch dredge.

7573. August 24, 1903. Gay Head S by W, Buoy No. 2, Quicks Hole, in line with Dumpling Light; 8 fathoms; muddy; oyster dredge.

7574. August 24, 1903. Gay Head S by W ½ W, Nobska ENE; 10 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7575. August 24, 1903. Gay Head SW by S ¾ S, Nobska NE by ¾ E; 12¾ fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7576. August 24, 1903. Gay Head SW ¾ S, Cuttyhunk Life Saving Station W by N ¾ N; 9½ fathoms sand and fine gravel; 7-foot beam trawl and 24-inch dredge.

Station no.

7577. August 24, 1903. Cuttyhunk Life Saving Station NW by W ¾ W, Gay Head SW ¼ S; 8 fathoms; fine gravel and broken shells; 7-foot beam trawl and 24-inch dredge.

7578. August 24, 1903. Gay Head SW by W, Cuttyhunk Life Saving station NW by W ½ W; 14 fathoms; sand and mud; 7-foot beam trawl and 24-inch dredge.

7579. August 24, 1903. Gay Head WSW, Tarpaulin Cove N by E ¾ E; 10½ fathoms; sandy; 7-foot beam trawl, 24-inch dredge.

7580. August 24, 1903. Gay Head W ¾ S, Tarpaulin Cove N by E; 9¾ fathoms; sandy; 7-foot beam trawl, 24-inch dredge.

7581. August 27, 1903. Gay Head S ¼ W, Cuttyhunk Life Saving Station NW by N ¼ N; 6¾ fathoms; black mud and shells; 7-foot beam trawl and 24-inch dredge.

7582. August 27, 1903. Gay Head S by E, Black Buoy on Devils Bridge SW; 14¾ fathoms; mud and shells; 7-foot beam trawl and 24-inch dredge.

7583. August 27, 1903. Cuttyhunk Light NW ½ W, Black Buoy S ¼ W; 13 fathoms; sand and shells; 7-foot beam and trawl and 24-inch dredge.

7584. August 27, 1903. Gay Head SSE, Cuttyhunk Light NW by W; 14¾ fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7585. August 28, 1903. Gay Head SE by S ¾ S, tangent Cuttyhunk Island WNW; 15 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7586. August 28, 1903. Gay Head SSE ¼ E, tangent Cuttyhunk Island W by N ½ N; 13 fathoms; sand and mud; 7-foot beam trawl and 24-inch dredge.

7587. August 28, 1903. Gay Head SE by S ¾ S, tangent Cuttyhunk Island W ¼ N; 10 fathoms; coarse gravel; oyster dredge.

7588. August 28, 1903. Gay Head S by E ¼ E, tangent Cuttyhunk Island W ¼ N; 10 fathoms, sand; oyster dredge.

7589. August 28, 1903. Gay Head S ¾ E, tangent Cuttyhunk Island W by N; 13 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7590. August 28, 1903. Gay Head S ½ E, Nobska NE by E ¾ E; 14¾ fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7591. August 28, 1903. Gay Head S ¼ W, tangent Cuttyhunk Island WNW; 14 fathoms; sand; 7-foot beam trawl and 24-inch dredge.

7592. August 28, 1903. Gay Head S by W ¾ W, tangent Cuttyhunk Island NW by W ¼ W; 16 fathoms; broken shells; 7-foot beam trawl and 24-inch dredge.

7593. August 28, 1903. Gay Head SW, tangent Cuttyhunk NW by W; 13 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7594. August 28, 1903. Gay Head SW by W ¾ W, Nobska NE ½ E; 10 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7595. September 1, 1903. Gay Head S ¼ W, bell buoy E by N; 7 fathoms; stones and gravel; oyster dredge.

7596. September 1, 1903. Gay Head S ¾ W, Nobska NE by E ¾ E; 7 fathoms; hard sand and rock; 7-foot beam trawl, 24-inch dredge, and oyster dredge.

7597. September 1, 1903. Nobska NE by E ½ E, Gay Head SW by S ¾ S; 12 fathoms; sandy; 7-foot beam trawl and 24-inch dredge.

7598. September 1, 1903. Nobska NE by E ½ E, Gay Head SW by S ½ S; 13 fathoms; sandy; 7-foot beam trawl, oyster dredge.

7599. September 1, 1903. Gay Head SW ½ S, Cuttyhunk Life Saving Station NW ¾ W, 12½ fathoms; black mud; 7-foot beam trawl,

7600. September 1, 1903. Gay Head SW by W ¼ W, Tarpaulin Cove NE by N ½ N; 10 fathoms; hard sand; 7-foot beam trawl.

7601. September 1, 1903. Gay Head W by S ¼ S, Nobska NE; 10 fathoms; muddy sand; oyster dredge.

7602. September 1, 1903. Gay Head W, Nobska NE ¼ N; 7 fathoms; muddy sand; 7-foot beam trawl and 24-inch dredge.

7603. September 2, 1903. Chatham Light WNW, 7 miles 17? fathoms; stones and pebbles; 7-foot beam trawl and small scrape dredge; drift S ⅛ mile.

Station no.

7604. September 2, 1903. Chatham Light W by N ¾ N, distance 7 miles; 19 fathoms; sand and gravel; oyster dredge; drift W ⅛ mile.

7605. September 2, 1903. Chatham Light W by N ¾ N, distance 7 miles; 17 fathoms; pebbles and gravel; oyster dredge; drift SE ⅛ mile.

7606. September 2, 1903. Chatham Light W by N ¾ N; 7 miles; 16 fathoms; large stones and gravel; oyster dredge; drift SE ⅛ mile.

7607. September 2, 1903. Chatham Light NW by W ½ W, 7 miles; 16¾ fathoms; large stones and gravel; oyster dredge; drift WSW ⅛ mile.

7608. September 2, 1903. Chatham Light WNW, 7¾ miles; 19¾ fathoms; sand and gravel; 7-foot beam trawl and small scrape dredge (3 separate hauls were made); drift SSW ⅛ mile.

7609. September 2, 1903. Chatham Light W ¼ N, 7¼ miles; 25 fathoms; shells and pebbles; oyster dredge; drift SE ¼ mile.

7610. July 22, 1904. South end Big Weepecket W by S ¾ S, 2 miles; Nobska Light SE by E ½ E, 2⅛ miles; 4½ fathoms; sandy; 7-foot beam trawl; scrape dredge; drift SE ⅛ mile.

7611. July 22, 1904. Nobska Light SE ½ E, 3½ miles; 2 small Weepecket Islands in line, 1½ miles; 7½ fathoms; black mud; 7-foot beam trawl, scrape dredge; drift E ⅛ mile.

7612. July 22, 1904. Bird Island Light NNE, 6¾ miles; Fairhaven standpipe NW ¼ N, 7¾ miles; 7½ fathoms; black sandy mud; 7-foot beam trawl; scrape dredge; drift ENE ⅛ mile.

7613. July 22, 1904. Bird Island Light NE ¾ N, 6 miles; Fair Haven standpipe NW ½ N, 6¼ miles; 7 fathoms; black sandy mud; 7-foot beam trawl; scrape dredge; drift ENE ⅛ mile.

7614. July 22, 1904. Fairhaven standpipe NW, 5 miles; Angelica and Cormorant Point beacon in line, ⅞ mile; 5 fathoms; black muddy sand; 7-foot beam trawl, scrape dredge; drift E ⅛ mile.

7615. July 22, 1904. Bird Island Light NE by E ¾ E, 5¾ miles; Fair Haven standpipe NW ¼ W, 3½ miles; 3½ fathoms; black muddy sand; 7-foot beam trawl, scrape dredge; drift E ⅛ mile.

7616. July 25, 1904. North Weepecket Island W by S ¼ S, 3¼ miles; end of Quamquisset Point S by E ½ E, ¼ mile; 5½ fathoms; muddy sand; oyster dredge; drift E $\frac{1}{16}$ mile.

7617. July 25, 1904. Wings Neck Light NNE ¼ E, 7 miles; Mattapoisett Light NW by W, 6¾ miles; 7½ fathoms; black mud; 7-foot beam trawl; drift ENE ¼ mile.

7618. July 25, 1904. Wings Neck Light NE ½ N, 6¼ miles; Mattapoisett Light NW by N ½ N, 4¾ miles; 7 fathoms; soft black mud; 7-foot beam trawl; scrape dredge; drift ENE ¼ mile.

7619. July 25, 1904. Wings Neck Light NE by E ¼ E, 6¼ miles; Mattapoisett Light, NNW, 2¾ miles; 7 fathoms; soft black mud; 7-foot beam trawl; scrape dredge; drift ENE ¼ mile.

7620. July 25, 1904. Bird Island Light NE by E, 3¼ miles; Mattapoisett Light NW by N ¼ N, 1¾ miles; 4 fathoms; black muddy sand; oyster dredge; drift NE ⅛ mile.

7621. July 27, 1904. Wings Neck Light N ¾ E, 6¼ miles; Mattapoisett Light NW ¼ N, 7¾ miles; 5½ fathoms; coarse sand and shell fragments; oyster dredge; drift NNW ⅛ mile.

7622. July 27, 1904. Wings Neck Light N by E ¾ E, 5½ miles; Mattapoisett Light NW ¼ N, 6¼ miles; 7 fathoms; black muddy sand; 7-foot beam trawl; scrape dredge; drift NE ¼ mile.

7623. July 27, 1904. Wings Neck Light NE ¾ N, 4¾ miles; Mattapoisett NW ¼ W, 4¾ miles; 7 fathoms; black mud; 7-foot beam trawl, scrape dredge; drift N ¼ mile.

7624. July 27, 1904. Wings Neck Light NE by E, 4½ miles; Mattapoisett NW ½ W, 3¼ miles; 5½ fathoms; muddy sand and shell fragments; 7-foot beam trawl; scrape dredge; drift NE ¼ mile.

7625. July 27, 1904. Wings Neck Light E by N ½ N, 4¾ miles; Mattapoisett Light NW by W ½ W, 2 miles; 4¾ fathoms; muddy sand; oyster dredge; drift SSW ¼ mile.

7626. July 29, 1904. Wings Neck Light N by E, 4 miles; Mattapoisett Light NW by W ¼ W, 6½ miles; 4¾ fathoms; muddy sand and shell fragments; oyster dredge; drift SW ⅛ mile.

7627. July 29, 1904. Wings Neck Light NE by N, 3¼ miles; Bird Island Light N by W ¾ W, 2¾ miles; 5¼ fathoms; sandy; 7-foot beam trawl; scrape dredge; drift SW ¼ mile.

7628. July 29, 1904. Wings Neck Light NE by E ½ E, 3 miles; Bird Island Light N ½ W, 1⅜ miles; 4 fathoms; muddy sand and shell fragments; oyster dredge; drift SW ⅛ mile.

7629. July 29, 1904. Black Buoy on Bow Bells SSW ¼ W, ¾ mile; Bird Island Light E ½ N, ¾ mile; 4 fathoms; sandy mud; oyster dredge; drift SW ⅛ mile.

7630. August 1, 1904. Wings Neck Light N ¾ E, 2¼ miles; Bird Island Light NW ¼ W, 3 miles; 4 fathoms; sandy; oyster dredge; drift SW ⅛ mile.

Station no.

7631. August 1, 1904. Wings Neck Light NE ¼ E, 1¾ miles; Bird Island Light NW by W ¼ W, 1¾ miles; 5 fathoms; mud and shells; oyster dredge; drift SW ⅛ mile.

7632. August 1, 1904. Wings Neck Light E ¼ S, 2 miles; Bird Island Light SW by W ¼ W, ¾ miles; 3¼ fathoms; mud; oyster dredge; drift SW ⅛ mile.

7633. August 1, 1904. Wings Neck Light SE by E, 1¾ miles; Bird Island Light SW ¼ W, 1¾ miles; 3¼ fathoms; muddy sand; oyster dredge; drift SW ⅛ mile.

7634. August 1, 1904. Wings Neck Light SSE, 1¼ miles; Bird Island Light SW by W ¼ W, 2½ miles; 3¼ fathoms; sand and shell fragments; oyster dredge; drift SW ⅛ mile.

7635. August 1, 1904. Wings Neck NE by E ¼ E, ⅝ mile; Dry Ledge N by W ¾ W, 2 miles; 4¾ fathoms; muddy sand and shell fragments; oyster dredge; drift SW ⅛ mile.

7636. August 3, 1904. Nobska Light E by S ¼ S, 3¾ miles; Little Weepecket Island and Sippowisett Hotel in line SSE ¼ E; North Weepecket Island ½ mile; 7 fathoms; rocky with coarse sand; oyster dredge; scrape dredge; drift NW ⅛ mile.

7637. August 3, 1904. Nobska Light ESE, 5 miles; Sippowisett Hotel E ¾ N, 5¼ miles; 8 fathoms; black sandy mud; 7-foot beam trawl; oyster dredge; scrape dredge; drift E ¼ mile.

7638. August 3, 1904. Nobska Light SE by E ¼ E, 6½ miles; Mattapoisett Light N ½ E, 6 miles; 8 fathoms; black sandy mud; 7-foot beam trawl; oyster dredge; drift ENE ¼ mile.

7639. August 3, 1904. Nobska Light SE by E, 7¾ miles; Cormorant Rock Spindle NE by N, 2½ miles; 5½ fathoms; hard sand and rocks; oyster dredge; drift ENE ¼ mile.

7640. August 5, 1904. Large Weepecket Island NE ¾ E, 1½ miles; Clark's Point Fort NW ¾ N, 8¾ miles; 6 fathoms; black sandy mud; oyster dredge; drift NW ⅛ mile.

7641. August 5, 1904. North Weepecket Island, E ½ N, 2½ miles; Clark's Point Fort NW by N, 7⅜ miles; 7½ fathoms; soft sandy mud; 7-foot beam trawl; scrape dredge; drift SSE ¼ mile

7642. August 5, 1904. Sippowissett Hotel E ¾ N, 7¾ miles; Clark's Point Fort NW by N, 5¾ miles; 8 fathoms; soft black mud; oyster dredge; drift SSE ¼ mile.

7643. August 5, 1904. Clark's Point Fort NW by N 4¼ miles; Sippowissett Hotel E ¾ S, 8 miles; 7 fathoms; mud and muddy sand; beam trawl; oyster dredge; drift SSE ¼ mile.

7644. August 5, 1904. Dumpling Rock Light W by S, 3¼ miles; Clark's Point Fort NW by N, 3 miles; 5½ fathoms; sand and mud; beam trawl; scrape dredge; oyster dredge; drift SSE ⅛ mile.

7645. August 8, 1904. Lookout on West Island E by S ½ S, 2⅛ miles; Butlers Flat Light NW, ½ mile; 4 fathoms; muddy sand with many cinders; oyster dredge; drift SW ⅛ mile.

7646. August 8, 1904. Dumpling Rock Light SW ½ S, 3 miles; Sconticut Neck Beacon SE by E ½ E, 1¼ miles; 5 fathoms; soft sticky mud; oyster dredge; drift SW ⅛ mile.

7647. August 8, 1904. Dumpling Rock Light SW ¾ W, 3 miles; Clark's Point Fort NW ¾ N, 1½ miles; 6 fathoms; soft sandy mud; oyster dredge; drift SW ⅛ mile.

7648. August 8, 1904. Clark's Point Fort N by E ¼ E, 1 mile; bell and black can buoy in line, SE ¾ E, 2¼ miles; 4¾ fathoms; sandy and many cinders; oyster dredge; drift SW ⅛ mile.

7649. August 8, 1904. Dumpling Rock Light SW, ⅞ mile; Barekneed Rocks Spindle NW by W ½ W, 1 mile; 5½ fathoms; soft mud; oyster dredge; drift SW ⅛ mile.

7650. August 8, 1904. Dumpling Rock Light W ¾ S, 1⅜ miles; Clark's Point Fort N ¼ E, 2¾ miles; 7 fathoms; sandy mud; oyster dredge; drift SW ⅛ mile.

7651.[a] August 11, 1904. North Rock and tangent of Pasque Island in line, 1⅜ miles; Lone Rocks Bell Buoy W by N ½ N, 1¼ miles; 7½ fathoms; soft black mud; oyster dredge.

7652. August 11, 1904. Lone Rock buoy W ¾ S, 2⅞ miles; south end Big Weepecket Island NE by E ¾ E, 3⅛ miles; 7 fathoms; soft sandy mud; oyster dredge; drift NW ⅛ mile.

7653. August 11, 1904. Lone Rock buoy SW ½ W, 2⅝ miles; North Weepecket Island E by N, 4⅛ miles; 8 fathoms; black sandy mud; beam trawl, scrape dredge; drift SW ¼ mile.

7654. August 11, 1904. West end Penikese Island SW by W, 5 miles; Dumpling Rock Light NW ¾ W, 3⅞ miles; 9 fathoms; black sandy mud; 7-foot beam trawl, scrape dredge; drift SW ¼ mile.

7655. August 11, 1904. West end Penikese Island SW ½ S, 5¼ miles; Dumpling Rock Light WNW, 2⅜ miles; 7½ fathoms; black sandy mud; oyster dredge; drift SW ¼ mile.

7656. August 12, 1904. North end Penikese Island W by S, 3½ miles; Dumpling Rock Light NNW ¾ W, 4⅞ miles; 8 fathoms; sandy mud; 7-foot beam trawl, scrape dredge; drift NE ⅛ mile.

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[a] This station as plotted on the chart is considerably nearer shore than the bearings given would indicate.

Station no.

7657. August 12, 1904. North end Penikese Island SW ½ W, 3¼ miles; Dumpling Rock Light NNW ½ W, 3¼ miles; 8 fathoms; sandy mud; 7-foot beam trawl, scrape dredge; drift SW ¼ mile.

7658. August 12, 1904. Hen and Chickens Lightship SW by W ¾ W, 6⅝ miles; Dumpling Rock Light NNW, 1¾ miles; 9 fathoms; black mud; oyster dredge.

7659. August 12, 1904. Mishaum Point SW by W ½ W, 1¾ miles; Dumpling Rock Light NNE, ⅜ mile; 5¼ fathoms; rocky, with gravel and shell fragments; oyster dredge; drift SW ⅛ mile.

7660. August 12, 1904. Hens and Chickens Lightship SW by W ½ W, 4¾ miles; Dumpling Rock Light NNE ½ E, 2⅜ miles; 7½ fathoms; muddy; 7-foot beam trawl, scrape dredge; drift SW ⅛ mile.

7661. August 12, 1904. Hen and Chickens Lightship W by S, 5¼ miles; Dumpling Rock Light N ¼ E, 3⅜ miles; 13½ fathoms; muddy; 7-foot beam trawl, scrape dredge; drift SW ¼ mile.

7662. August 12, 1904. Hen and Chickens Lightship W ¼ N, 6 miles; Dumpling Rock Light N ½ W, 4¾ miles; 10 fathoms; soft mud; 7-foot beam trawl, scrape dredge; drift SW ¼ mile.

7663. August 12, 1904. North Rock E by N ¾ N, ½ mile; Dumpling Rock Light N by W ¼ W, 6 miles; 7 fathoms; mud and shells; 7-foot beam trawl, scrape dredge; drift SW ⅛ mile.

7664. August 15, 1904. Cuttyhunk Light E ¾ N, ⅝ mile; Hen and Chickens Lightship NW ¾ N, 3⅜ miles; 12 fathoms: small stones; oyster dredge; drift SW ⅛ mile.

7665. August 15, 1904. Cuttyhunk Light SE by E 1⅝ miles; Hen and Chickens Lightship NW ¾ N, 2⅛ miles; 11½ fathoms; rocky and sandy; oyster dredge; drift SW ⅛ mile.

7666. August 15, 1904. North end Penikese Island E, 4 miles; Hen and Chickens Lightship NW ¾ N, ¾ mile; 11 fathoms; rocky and small stones; oyster dredge; drift SW ⅛ mile.

7667. August 15, 1904. Dumpling Rock Light NE by E, 6⅞ miles; Hen and Chickens Lightship SE by S ½ S, ¾ mile; 9 fathoms; small stones; oyster dredge; drift SW ⅛ mile.

7668. August 15, 1904. Mishaum Point NE by E ¾ E, 3¼ miles; Cuttyhunk Light SSE, 5 miles; 8 fathoms; muddy sand; oyster dredge; drift SW ⅛ mile.

7669. August 15, 1904. Dumpling Rock Light NE, 5⅜ miles; Cuttyhunk Light S by E ¾ E, 3⅜ miles; 13 fathoms; black sandy mud; oyster dredge.

7670. August 15, 1904. Dumpling Rock Light NE by N ¼ N, 6 miles; north end Penikese Island E ½ N, 2 miles; 19 fathoms(?); small stones; oyster dredge; drift SW ⅛ mile.

7671. August 15, 1904. Cuttyhunk Life-Saving Station SE by E ½ E, 1¼ miles; Cuttyhunk Light SW ¾ S, 1 mile; 9 fathoms; stones and muddy sand; 7-foot beam trawl, oyster dredge; drift SW ¼ mile.

7672. August 17, 1904. Cuttyhunk Light SW by S, 2⅝ miles; Hen and Chickens Lightship W ½ N, 4 miles; 10 fathoms; small stones, sand, and shells; oyster dredge; drift SW ⅛ mile.

7673. August 17, 1904. Cuttyhunk Light S ¾ W, 3½ miles; Hen and Chickens Lightship W by S, 3¼ miles; 17 fathoms; sandy mud and stones; beam trawl, scrape dredge; drift SW ¼ mile.

7674. August 17, 1904. Dumpling Rock Light NE ½ E, 4 miles; Cuttyhunk Life-Saving Station SE by S ½ S, 4¾ miles; 7 fathoms; coarse sand and mud; oyster dredge; drift SW ¼ mile.

7675. August 17, 1904. Mishaum Point E by N, 2 miles; Hen and Chickens Lightship SW by S ½ S, 3⅜ miles; 6¾ fathoms; muddy sand; beam trawl, oyster dredge; drift SW ⅛ mile.

7676. July 17, 1905. Gay Head Light SW ¼ S, Prospect Hill SE by E ¼ E; 9½ fathoms; hard sand; 7-foot beam trawl.

7677. July 17, 1905. Gay Head Light S by W ½ W, Prospect Hill ESE ⅛ E, 11½ fathoms; hard sand; 7-foot beam trawl; scrape dredge.

7678. July 17, 1905. Prospect Hill SE by S, Gay Head Light SW ¾ W, 12½ fathoms; hard sand; 7-foot beam trawl, scrape dredge. (Very little in the scrape dredge.)

7679. July 24, 1905. (*a*) Pasque-Nashawena 40° 47′, Nashawena-Cuttyhunk 27° 05′; (*b*) Pasque-Nashawena 38° 36′, Nashawena-Cuttyhunk 23° 44′; 13½ fathoms; sand and shells; 6-foot beam trawl and scrape dredge.

7680. July 24, 1905. (*a*) Pasque-Nashawena 33° 22′, Nashawena-Cuttyhunk 22° 30′; (*b*) Pasque-Nashawena 33° 35′, Nashawena-Cuttyhunk 22° 20′; (*c*) Pasque-Nashawena 32° 47′, Nashawena-Cuttyhunk 22° 19′; 13½ fathoms; hard sand; 6-foot trawl and scrape dredge.

7681. July 24, 1905. (*a*) Pasque-Nashawena 35° 56′, Nashawena-Cuttyhunk 31° 05′; (*b*) Pasque-Nashawena 34° 41′; Nashawena-Cuttyhunk 29° 11′; (*c*) Pasque-Nashawena 33° 05′, Nashawena-Cuttyhunk 28° 08′; 13½ fathoms; hard sand; 6-foot trawl; scrape dredge.

Station no.

7682. July 24, 1905. (*a*) Pasque-Nashawena 37° 40′, Nashawena-Cuttyhunk 19° 07′; (*b*) Tarpaulin Cove-Nashawena 89° 08′, Nashawena-Gay Head 95° 09′; (*c*) Tarpaulin Cove-Nashawena 91° 09′; Nashawena-Gay Head 89° 37′; 19 fathoms(?); hard sand, mud, and shells; 6-foot trawl and scrape dredge.

7683. July 26, 1095. (*a*) Gay Head-Nashawena 127° 48′, Nashawena-Cuttyhunk 61° 07′; (*b*) Gay Head-Nashawena 120° 50′, Nashawena-Cuttyhunk 60° 00′; (*c*) Gay Head-Nashawena 114° 41′, Nashawena-Cuttyhunk 61° 45′; 19½(?) fathoms; hard sand; 7-foot beam trawl, mud bag and oyster dredge.

7684. July 26, 1905. (*a*) Gay Head-Nashawena 105° 43′, Nashawena-Cuttyhunk 59° 40′; (*b*) Gay Head-Nashawena 100° 30′, Nashawena-Cuttyhunk 57° 33′; (*c*) Gay Head-Nashawena 94° 13′, Nashawena-Cuttyhunk 55° 43′; 13½ fathoms; hard sand; 7-foot beam trawl, mud bag, oyster dredge.

7685. July 26, 1905. (*a*) Gay Head-Nashawena 129° 44′, Nashawena-Cuttyhunk 75° 42′; (*b*) Gay Head-Nashawena 123° 46′, Nashawena-Cuttyhunk 75° 20′; (*c*) Gay Head-Nashawena 116° 59′, Nashawena-Cuttyhunk 77° 46′; 17 fathoms; hard sand; 7-foot beam trawl, mud bag, and oyster dredge.

7686. July 26, 1905. (*a*) Gay Head-Nashawena 102° 34′, Nashawena-Cuttyhunk 73° 55′; (*b*) Gay Head-Nashawena 99° 42′, Nashawena-Cuttyhunk 71° 15′; (*c*) Gay Head-Nashawena 93° 52′, Nashawena-Cuttyhunk 68° 34′; 17½ fathoms; hard sand; 7-foot beam trawl, mud bag, and oyster dredge.

7687. July 26, 1905. (*a*) Gay Head-Nashawena 105° 11′, Nashawena-Cuttyhunk 109° 25′; (*b*) Gay Head-Nashawena 103° 67′, Nashawena-Cuttyhunk 104° 43′; (*c*) Gay Head-Nashawena 97° 52′, Nashawena-Cuttyhunk 103° 23′; 12 fathoms; hard sand; 7-foot beam trawl, mud bag, oyster dredge.

7688. July 26, 1905. (*a*) Gay Head-Nashawena 90° 36′, Nashawena-Cuttyhunk 96° 36′; (*b*) Gay Head-Nashawena 85° 42′, Nashawena-Cuttyhunk 90° 57′; (*c*) Gay Head-Nashawena 79° 59′, Nashawena-Cuttyhunk 90° 38′; (*d*) Gay Head-Nashawena 76° 37′, Nashawena-Cuttyhunk 92° 44′; 13 fathoms; hard, coarse sand; 7-foot beam trawl, mud bag, oyster dredge.

7689. July 26, 1905. (*a*) Nashawena-Cuttyhunk Life Saving Station 92° 12′, Life-Saving Station-Cuttyhunk Light 46° 59′; (*b*) Nashawena-Cuttyhunk Life-Saving Station 69° 21′, Life-Saving Station-Cuttyhunk Light 54° 40′; (*c*) Nashawena-Cuttyhunk Life-Saving Station 59° 20′, Life-Saving Station-Cuttyhunk Light 57° 46′; 9 fathoms; hard sand and rocks; 7-foot beam trawl, mud bag, oyster dredge.

7690. July 26, 1905. (*a*) Gay Head-Nashawena 70° 11′, Nashawena-Cuttyhunk 106° 47′; (*b*) Gay Head-Nashawena 71° 03′, Nashawena-Cuttyhunk 106° 57′; (*c*) Gay Head-Nashawena 71° 14′, Nashawena-Cuttyhunk 93° 31′; 9 fathoms; rocky; 7-foot beam trawl, mud bag, oyster dredge.

7691. July 26, 1905. (*a*) Gay Head-Nashawena 69° 46′, Nashawena-Cuttyhunk 119° 59′; (*b*) Gay Head-Nashawena 70° 33′, Nashawena-Cuttyhunk 113° 58′; 9 fathoms; rocky; 7-foot beam trawl, mud bag, oyster dredge.

7692. July 26, 1905. (*a*) Gay Head-Nashawena 61° 57′, Nashawena-Cuttyhunk 80° 86′; (*b*) Gay Head-Nashawena 60° 40′, Nashawena-Cuttyhunk 72° 07; 9 fathoms, rosky; 7-foot beam trawl, mud bag, oyster dredge.

7693. July 26, 1905. (*a*) Gay Head-Nashawena 82° 15′, Nashawena-Cuttyhunk 132° 50′; (*b*) Gay Head-Nashawena 87° 44′, Nashawena-Cuttyhunk 132° 59′; (*c*) Nashawena-Cuttyhunk Life-Saving Station 117° 41′, Life-Saving Station-Cuttyhunk Light 11° 55′; 11 fathoms; rocky bottom; 7-foot beam trawl, oyster dredge, mud bag.

7694. July 26, 1905. (*a*) Naushon SW-Nashawena 46° 37′, Nashawena-Cuttyhunk 99° 32′; (*b*) Naushon SW-Nashawena 80° 13′, Nashawena-Cuttyhunk 66° 06′; (*c*) Naushon SW-Pasque 29° 01′, Pasque Nashawena 82° 13′; 12½ fathoms; rocky; 7-foot beam trawl, mud bag, oyster dredge.

7695 July 26, 1905. (*a*) Naushon SW-Pasque 51° 25′, Pasque-Nashawena 90° 38′; (*b*) Naushon SW-Pasque 61° 47′, Pasque-Nashawena 80° 03′; (*c*) Naushon SW-Pasque 66° 59′, Pasque-Nashawena 71° 56′; 10½ fathoms; sandy; 7-foot beam trawl, mud bag, oyster dredge.

7696. July 26, 1905. (*a*) Naushon SW-Pasque 81° 18′, Pasque-Nashawena 56° 28′; (*b*) Naushon SW-Pasque 85° 04′, Pasque-Nashawena 47° 40′; (*c*) Naushon SW-Pasque 81° 31′, Pasque-Nashawena 41° 33′; 10 fathoms; sandy; 7-foot beam trawl, mud bag, oyster dredge.

Station no.

7697. July 26, 1905. (*a*) Tarpaulin Cove-Naushon SW 36° 41′, Naushon SW-Pasque 66° 33′; (*b*) Tarpaulin Cove-Naushon SW 56° 34′, Naushon SW-Pasque 45° 39′; (*c*) Tarpaulin Cove-Naushon SW 66° 00′, Naushon SW-Pasque 32° 43′; sand and mud; 7-foot beam trawl, mud bag, and oyster dredge.

7698. July 28, 1905. (*a*) Nashawena-Gay Head 90° 02′, Gay Head-Prospect Hill 75° 27; (*b*) Nashawena-Gay Head 89° 33′, Gay Head-Prospect Hill 73° 21′; (*c*) Nashawena-Gay Head 87° 06′, Gay Head-Prospect Hill 71° 14′; (*d*) Nashawena-Gay Head 84° 45′; Gay Head-Prospect Hill 69° 56′; 12 fathoms; sandy.

7699. July 28, 1905. (*a*) Nashawena-Gay Head 87° 33′, Gay Head-Prospect Hill 68° 49′; (*b*) Nashawena-Gay Head 91° 08′, Gay Head-Prospect Hill 68° 31′; (*c*) Nashawena-Gay Head 93° 22′, Gay Head-Prospect Hill 67° 41′; 10 fathoms; hard sand.

7700. July 28, 1905. (*a*) Nashawena-Gay Head 92° 20′, Gay Head-Prospect Hill 66° 35′; (*b*) Nashawena-Gay Head 98° 39′, Gay Head-Prospect Hill 64° 17′; (*c*) Nashawena-Gay Head 99° 16′, Gay Head-Prospect Hill 62° 54′; (*d*) Nashawena-Gay Head 99° 52′, Gay Head-Prospect Hill 61° 19′; 10 fathoms; sand.

7701. July 28, 1905. (*a*) Nashawena-Gay Head 101° 35′, Gay Head-Prospect Hill 58° 19′; (*b*) Nashawena-Gay Head 101° 36′, Gay Head-Prospect Hill 56° 31′; (*c*) Nashawena-Gay Head 101° 01′, Gay Head-Prospect Hill 54° 45′; (*d*) Nashawena-Gay Head 100° 55′, Gay Head-Prospect Hill 53° 17′; 13 fathoms; sand.

7702. July 28, 1905. (*a*) Nashawena-Gay Head 121° 43′, Gay Head-Prospect Hill 68° 43′; (*b*) Nashawena-Gay Head 124° 15′, Gay Head-Prospect Hill 66° 01′; (*c*) Nashawena-Gay Head 125° 25′, Gay Head-Prospect Hill 64° 02′; (*d*) Nashawena-Gay Head 126° 27′, Gay Head-Prospect Hill 62° 26′; 13 fathoms; sand.

7703. July 28, 1905. (*a*) Nashawena-Gay Head 129° 05′, Gay Head-Prospect Hill 55° 23′; (*b*) Nashawena-Gay Head 129° 20′, Gay Head-Prospect Hill 53° 00′; (*c*) Nashawena-Gay Head 129° 45′, Gay Head-Prospect Hill 51° 36′; (*d*) Nashawena-Gay Head 129° 55′, Gay Head-Prospect Hill 50° 08′; 12 to 7 fathoms; sand.

7704. July 31, 1905. (*a*) Pasque-Nashawena 72° 12′, Nashawena-Cuttyhunk 43° 23′; (*b*) Pasque-Nashawena 63° 47′, Nashawena-Cuttyhunk 47° 44′; (*c*) Pasque-Nashawena 57° 55′; Nashawena-Cuttyhunk 49° 37′; 10¼ fathoms; sand.

7705. July 31, 1905. (*a*) Pasque-Nashawena 53° 47′, Nashawena-Cuttyhunk 43° 55′; (*b*) Pasque-Nashawena 51° 32′; Nashawena-Cuttyhunk 41° 20′; (*c*) Pasque-Nashawena 48° 52′, Nashawena-Cuttyhunk 39° 53′; 7½ fathoms; sand.

7706. July 31, 1905. (*a*) Pasque-Nashawena 43° 33′, Nashawena-Cuttyhunk 38° 13′; (*b*) Pasque-Nashawena 41° 52′, Nashawena-Cuttyhunk 37° 24′; (*c*) Pasque-Nashawena 40° 16′, Nashawena-Cuttyhunk 36° 02′; (*d*) Pasque-Nashawena 38° 49′, Nashawena-Cuttyhunk 34° 55′; 13½ fathoms; sand.

7707. July 31, 1905. (*a*) Pasque-Cuttyhunk 63° 41′, Cuttyhunk-Gay Head 131° 22′; (*b*) Pasque-Nashawena (rejected), Nashawena-Cuttyhunk (rejected); (*c*) Pasque-Nashawena 29° 26′; Nashawena-Cuttyhunk 38° 25′; 15 fathoms; sand.

7708. July 31, 1905. (*a*) Pasque-Nashawena 30° 23′, Nashawena-Cuttyhunk 41° 34′; (*b*) Pasque-Nashawena 31° 14′, Nashawena-Cuttyhunk 43° 51′; (*c*) Pasque-Nashawena 32° 27′, Nashawena-Cuttyhunk 44° 32′; 13½ fathoms; sand.

7709. July 31, 1905. (*a*) Pasque-Nashawena 33° 35′, Nashawena-Cuttyhunk 48° 02′; (*b*) Pasque-Nashawena 33° 41′, Nashawena-Cuttyhunk 51° 10′; (*c*) Pasque-Nashawena 34° 43′, Nashawena-Cuttyhunk 53° 15′; 13½ fathoms; sand.

7710. July 31, 1905. (*a*) Pasque-Nashawena 30° 26′, Nashawena-Cuttyhunk 65° 37′; (*b*) Pasque-Nashawena 27° 51′, Nashawena-Cuttyhunk 71° 53′; (*c*) Pasque-Nashawena 26° 10′, Nashawena-Cuttyhunk 75° 23′; (*d*) Pasque-Nashawena 25° 47′, Nashawena-Cuttyhunk 77° 02′; 13½ fathoms; fine sand.

7717. August 4, 1905. (*a*) Naushon SW-Nashawena 45° 16′; Nashawena-Cuttyhunk 52° 46′; (*b*) Naushon SW-Nashawena 46° 57′, Nashawena-Cuttyhunk 50° 12′; (*c*) Naushon SW-Nashawena 48° 15′, Nashawena-Cuttyhunk 48° 27′; 13½ fathoms; sand; beam trawl and scrape dredge.

Station no.

7718. August 4, 1905. (*a*) Naushon SW-Nashawena 43° 32′, Nashawena-Cuttyhunk 45° 55′; (*b*) Naushon SW-Nashawena 43° 59′, Nashawena-Cuttyhunk 44° 25′; (*c*) Naushon SW-Nashawena 44° 17′, Nashawena-Cuttyhunk 43° 26′, 14 fathoms; sand and shells; beam trawl and scrape dredge.

7719. August 4, 1905. (*a*) Naushon SW-Nashawena 43° 01′, Nashawena-Cuttyhunk 40° 30′; (*b*) Naushon SW-Nashawena 42° 57′, Nashawena-Cuttyhunk 39° 47′; (*c*) Naushon SW-Nashawena 42° 57′, Nashawena-Cuttyhunk 39° 15′; (*d*) Naushon SW-Nashawena 42° 57′, Nashawena-Cuttyhunk 38° 48′; 17 fathoms; sand and shells; beam trawl and scrape dredge.

7720. August 4, 1905. (*a*) Naushon SW-Nashawena 42° 51′, Nashawena-Cuttyhunk 37° 31′; (*b*) Naushon SW-Nashawena 42° 00′, Nashawena-Cuttyhunk 37° 08′; (*c*) Naushon SW-Nashawena 41° 01′, Nashawena-Cuttyhunk 37° 12′; 13½ fathoms; sand and shells; beam trawl and scrape dredge.

7721. August 4, 1905. (*a*) Naushon SW-Nashawena 32° 50′, Nashawena-Cuttyhunk 51° 13′; (*b*) Naushon SW-Nashawena-33° 15′, Nashawena-Cuttyhunk 49° 30′; (*c*) Naushon SW-Nashawena 33° 47′, Nashawena-Cuttyhunk 47° 39′; 11 fathoms; sandy; beam trawl and scrape dredge.

7722. August 4, 1905. (*a*) Naushon SW-Nashawena 37° 27′, Nashawena-Cuttyhunk 40° 51′; (*b*) Naushon SW-Nashawena 37° 55′, Nashawena-Cuttyhunk 39° 30′; (*c*) Naushon SW-Nashawena 38° 12′, Nashawena-Cuttyhunk 38° 28′; 13 fathoms; hard sand; beam trawl and scrape dredge.

7723. August 4, 1905. (*a*) Cuttyhunk-Gay Head 77° 59′, Gay Head-Prospect Hill 126° 35′; (*b*) (rejected); (*c*) Cuttyhunk Life-Saving Station-Gay Head 88° 24′, Gay Head-Prospect Hill 112° 33′; 13 fathoms; hard sand.

7724. August 8, 1905. (*a*) Gay Head-Prospect Hill 141° 44′, Prospect Hill-tangent Cedar Tree Neck 66° 58′; (*b*) Gay Head-Prospect Hill 133° 35′, Prospect Hill-tangent Cedar Tree Neck 69° 42′; (*c*) Gay Head-Prospect Hill 127° 29′, Prospect Hill-tangent Cedar Tree Neck 72° 15′; 10 fathoms; hard sand; 9-foot beam trawl, mud bag.

7725. August 8, 1905. (*a*) Gay Head-Prospect Hill 116° 32′, Prospect Hill-tangent Cedar Tree Neck 75° 49′; (*b*) Gay Head-Prospect Hill 111° 44′, Prospect Hill-tangent Cedar Tree Neck 76° 55′; (*c*) Gay Head-Prospect Hill 108° 59′, Prospect Hill-tangent Cedar Tree Neck 76° 25′; 10 fathoms; hard sand; 9-foot beam trawl and mud bag.

7726. August 8, 1905. (*a*) Gay Head-Prospect Hill 105° 24′, Prospect Hill-Tarpaulin Cove 111° 33′; (*b*) Gay Head-Prospect Hill 102° 57′, Prospect Hill-Tarpaulin Cove 108° 41′; (*c*) Gay Head-Prospect Hill 100° 44′, Prospect Hill-Tarpaulin Cove 106° 59′; 15 to 13½ fathoms; sandy mud; 9-foot beam trawl and mud bag.

7727. August 8, 1905. (*a*) Gay Head-Prospect Hill 93° 07′, Prospect Hill-Tarpaulin Cove 103° 56′; (*b*) Gay Head-Prospect Hill 89° 45′, Prospect Hill-Tarpaulin Cove 103° 31′; (*c*) Gay Head-Prospect Hill 87° 21′, Prospect Hill-Tarpaulin Cove 103° 18′; 12 fathoms; hard sand; 9-foot beam trawl and mud bag.

7728. August 8, 1905. (*a*) Prospect Hill-Pasque 98° 45′, Pasque-Gay Head 83° 03′; (*b*) Prospect Hill-Pasque 104° 51′, Pasque-Gay Head 88° 23′; (*c*) Prospect Hill-Pasque 107° 45′, Pasque-Gay Head 90° 57′; 8 fathoms; sticky mud; 9-foot beam trawl and mud bag.

7729. August 8, 1905. (*a*) Prospect Hill-Pasque 116° 51′, Pasque Gay-Head 101° 01′; (*b*) Gay Head-Prospect Hill 134° 30′, Prospect Hill-tangent Cedar Tree Neck 50° 52′; (*c*) Gay Head-Prospect Hill 129° 24′, Prospect Hill-tangent Cedar Tree Neck 50° 52′; 10½ fathoms; hard sand; 9-foot beam trawl and mud bag.

7730. August 8, 1905. (*a*) Prospect Hill-Nashawena 115° 59′, Nashawena-Gay Head 87° 59′; (*b*) Prospect Hill-Pasque 92° 27′, Pasque-Gay Head 115° 22′; (*c*) Prospect Hill-Pasque 101° 57′, Pasque-Gay Head 118° 41′; 12 fathoms; hard sand; 9-foot beam trawl and mud bag.

7731. August 8, 1905. (*a*) Naushon SW-Nashawena 43° 17′, Nashawena-Cuttyhunk 30° 06′; (*b*) Naushon SW-Nashawena 42° 05′, Nashawena-Cuttyhunk 29° 48′; (*c*) Naushon SW-Nashawena 41° 35′, Nashawena Cuttyhunk 29° 39′; 12 fathoms; hard sand; 9-foot beam trawl and mud bag.

7732. August 10, 1905. (*a*) Naushon SW-Tarpaulin Cove 59°26′, Tarpaulin Cove-Nashawena 37° 34′; (*b*) Naushon SW-Tarpaulin Cove 53° 01′, Tarpaulin Cove-Nashawena 38° 43′; (*c*) Naushon SW-Tarpaulin Cove 51° 32′; Tarpaulin Cove-Nashawena 40° 30′; 12½ fathoms; sand and pebbles; 9-foot beam trawl, scrape dredge.

Station no.

7733. August 10, 1905. (*a*) Naushon SW-Tarpaulin Cove 16° 40′, Tarpaulin Cove-Nashawena 67° 51′; (*b*) Naushon SW-Tarpaulin Cove 16° 42′, Tarpaulin Cove-Nashawena 63° 22′; (*c*) Naushon SW-Tarpaulin Cove 16° 18′, Tarpaulin Cove-Nashawena 58° 13′; 13 fathoms; pebbles; 9-foot beam trawl, scrape dredge.

7734. August 10, 1905. (*a*) Tarpaulin Cove-Naushon SW 31° 18′, Naushon SW-Pasque 52° 28′; (*b*) Tarpaulin Cove-Naushon SW 31° 47′, Naushon SW-Pasque 48° 48′; (*c*) Tarpaulin Cove-Naushon SW 31° 30′, Naushon SW-Pasque 45° 55′; 10½ fathoms; sand and shells; 9-foot beam trawl and scrape dredge.

7735. August 10, 1905. (*a*) Gay Head-Prospect Hill 66° 00′, Prospect Hill-Kopeecon Point 43° 57′; (*b*) Gay Head-Prospect Hill 68° 38′, Prospect Hill-Kopeecon Point 47° 21′, (*c*) Gay Head-Prospect Hill 71° 04′, Prospect Hill-Kopeecon Point 50° 31′; 9 fathoms; sand; 9-foot beam trawl and scrape dredge.

7736. August 10, 1905. (*a*) Prospect Hill-Kopeecon Point 56° 20′, Kopeecon Point-Tarpaulin Cove 112° 03′; (*b*) Prospect Hill-Kopeecon Point 60° 21′, Kopeecon Point-Tarpaulin Cove 108° 13′; (*c*) Kopeecon Point-Tarpaulin Cove 106° 24′; 13 fathoms; sand and shells; 9-foot beam trawl and scrape dredge.

7737. August 12, 1905. (*a*) Nobska-Naushon Tripod 120° 51′, Naushon Tripod-Tarpaulin Cove 32° 08′; (*b*) Nobska-Naushon Tripod 115° 18′, Naushon Tripod-Tarpaulin Cove 32° 31′; (*c*) Nobska-Naushon Tripod 115° 15′, Naushon Tripod-Tarpaulin Cove 32° 51′; 12 fathoms; pebbles.

7738. August 12, 1905. (*a*) Nobska-Naushon Tripod 85° 18′, Naushon Tripod-Tarpaulin Cove 72° 44′; (*b*) Nobska-Naushon Tripod 83° 43′, Naushon Tripod-Tarpaulin Cove 71° 38′; (*c*) (Dredge caught). 12 fathoms; sand and gravel.

7739. August 12, 1905. (*a*) Nobska-Naushon Tripod 74° 21′, Naushon Tripod-Tarpaulin Cove 37° 56′; (*b*) Nobska-Naushon Tripod 70° 36′, Naushon Tripod-Naushon SW 61° 06′; (*c*) Nobska-Naushon Tripod 67° 14′, Naushon Tripod-Tarpaulin Cove 34° 38′; 8 fathoms; sand and gravel.

7740. August 12, 1905. (*a*) Kopeecon Point-Indian Hill 73° 16′, Indian Hill-Nortons Point 48° 02′; (*b*) Kopeecon Point-Indian Hill 78° 33′, Indian Hill-Nortons Point 46° 22′; (*c*) Kopeecon Point-Indian Hill 80° 03′, Indian Hill-Nortons Point 43° 10′; 15 fathoms; sand and gravel.

7741. August 12, 1905. (*a*) Prospect Hill-Indian Hill 112° 23′, Indian Hill-Nortons Point 22° 27′; (*b*) Prospect Hill-Indian Hill 108° 37′, Indian Hill-Nortons Point 21° 02′; (*c*) Prospect Hill-Indian Hill 102° 41′, Indian Hill-Nortons Point 21° 30′; 15 fathoms; sand and shells.

7742. August 17, 1905. (*a*) Nobska-Naushon Tripod 101° 34′, Naushon Tripod-Naushon SW 35° 47′; (*b*) Nobska-Naushon Tripod 99° 37′, Naushon Tripod-Naushon SW 35° 53′; 9 fathoms; rocky; 7-foot beam trawl, mud bag, oyster dredge.

7743. August 17, 1905. (*a*) Nobska-Naushon Tripod 99° 40′, Naushon Tripod-Naushon SW 37° 44′; (*b*) Nobska-Naushon Tripod 97° 42′, Naushon Tripod-Naushon SW 38° 01′; 10½ fathoms; pebbles; 7-foot beam trawl, mud bag, oyster dredge.

7744. August 17, 1905. (*a*) Nobska-Tarpaulin Cove 90° 58′, Tarpaulin Cove-Nashawena 31° 05′; (*b*) Nobska-Tarpaulin Cove 89° 37′, Tarpaulin Cove-Nashawena 31° 30′; (*c*) Nobska-Tarpaulin Cove 87° 39′, Tarpaulin Cove-Nashawena 32° 32′; 12½ fathoms; pebbles and shells; 7-foot beam trawl, mud bag, oyster dredge.

7745. August 17, 1905. (*a*) Nobska-Naushon Tripod 73° 55′, Naushon Tripod-Naushon SW 33° 46′; (*b*) Nobska-Naushon Tripod 73° 58′, Naushon Tripod-Naushon SW 31° 30′; (*c*) Nobska-Naushon Tripod 73° 17′, Naushon Tripod-Naushon SW 29° 52′; 12 to 8 fathoms; rocks and pebbles; 7-foot beam trawl, mud bag, oyster dredge.

7746. August 17, 1905. (*a*) Gay Head-Nortons Point 48° 20′, Nortons Point-West Chop 78° 24′; (*b*) Gay Head-Nortons Point 40° 09′, Nortons Point-West Chop 83° 17′; (*c*) Gay Head-Indian Hill 28° 33′, Indian Hill-West Chop 92° 18′; 15½ to 13½ fathoms; stones and gravel; 7-foot beam trawl, mud bag, oyster dredge.

7747. August 17, 1905. (*a*) Gay Head-Indian Hill 23° 16′, Indian Hill-West Chop 89° 40′; (*b*) Gay Head-Indian Hill 20° 11′, Indian Hill-West Chop 86° 16′; (*c*) Falmouth Observatory-Nobska 67° 45′, Nobska-Tarpaulin Cove 63° 46′; 14 fathoms; large stones; 7-foot beam trawl, mud bag, oyster dredge.

Station no.

7748. August 17, 1905. (*a*) Observatory-Nobska 82° 37′, Nobska-Tarpaulin Cove 43° 55′; (*b*) Falmouth Observatory-Nobska 79° 46′, Nobska-Tarpaulin Cove 38° 42′; (*c*) Falmouth Observatory-Nobska 75° 24′, Nobska-Tarpaulin Cove 37° 08′; 13 fathoms; pebbles and sand; 7-foot beam trawl, mud bag, oyster dredge.

7749. August 17, 1905. (*a*) Falmouth Observatory-Nobska 59° 30′, Nobska-Tarpaulin Cove 56° 11′; (*b*) Falmouth Observatory-Nobska 58° 02′, Nobska-Tarpaulin Cove 53° 05′; (*c*) Falmouth Observatory-Nobska 57° 03′, Nobska-Tarpaulin Cove 51° 33′; 10½ fathoms; hard sand; 7-foot beam trawl, mud bag, oyster dredge.

7750. August 17, 1905. (*a*) Falmouth Observatory-Nobska 50° 33′, Nobska-Tarpaulin Cove 56° 48′; (*b*) Falmouth Observatory-Nobska 50° 21′, Nobska-Tarpaulin Cove 58° 10′; sandy; 9-foot beam trawl, mud bag, oyster dredge.

7751. August 17, 1905. (*a*) Falmouth Observatory-Nobska 42° 31′, Nobska-Tarpaulin Cove 69° 45′; (*b*) Falmouth Observatory-Nobska 41° 10′, Noksba-Tarpaulin Cove 69° 28′; (*c*) Falmouth Observatory-Nobska 40° 48′, Nobska-Tarpaulin Cove 69° 10′; 9½ fathoms; sand; 9-foot beam trawl, mud bag, oyster dredge.

7752. August 17, 1905. (*a*) Falmouth Observatory-Nobska 32° 42′, Nobska-Tarpaulin Cove 87° 32′; (*b*) Falmouth Observatory-Nobska 31° 57′, Nobska-Tarpaulin Cove 86° 11′; (*c*) Falmouth Observatory-Nobska 31° 07′, Nobska-Tarpaulin Cove 85° 43′; 10 fathoms; sand and pebbles; 7-foot beam trawl, mud bag, oyster dredge.

7753. August 17, 1905. (*a*) Naushon SW-Indian Hill 66° 35′, Indian Hill-West Chop 75° 22′; (*b*) Naushon SW-Indian Hill 65° 28′, Indian Hill-West Chop 72° 52′; (*c*) Naushon SW-Indian Hill 64° 34′, Indian Hill-West Chop 71° 22′; 13½ fathoms; pebbles; 7-foot beam trawl, mud bag, oyster dredge.

7754. August 17, 1905. (*a*) Indian Hill-West Chop 76° 29′, West Chop-Falmouth Observatory 63° 53′; (*b*) Indian Hill-West Chop 73° 27′, West Chop-Falmouth Observatory 62° 43′; (*c*) Indian Hill-West Chop 72° 02′, West Chop-Falmouth Observatory 62° 22′; 13½ fathoms; pebbles and sand; 7-foot beam trawl, mud bag, oyster dredge.

7755. August 17, 1905. (*a*) Falmouth Observatory-Nobska 95° 43′, Nobska-Naushon SW 61° 26′; (*b*) Falmouth Observatory-Nobska 98° 11′, Nobska-Naushon SW 62° 27′; (*c*) Falmouth Observatory-Nobska 98° 45′, Nobska-Naushon SW 65° 45′; (*d*) Falmouth Observatory-Nobska 97° 05′, Nobska-Naushon SW 70° 51′; 10 fathoms; sand and gravel; 7-foot beam trawl, mud bag, oyster dredge.

7756. August 21, 1905. (*a*) Falmouth Observatory-Nobska 88° 05′, Nobska-Tarpaulin Cove 53° 14′; (*b*) Falmouth Observatory-Nobska 84° 58′, Nobska-Tarpaulin Cove 52° 05′; (*c*) Falmouth Observatory-Nobska 80° 15′, Nobska-Tarpaulin Cove 54° 33′; 11½ fathoms; stones and pebbles; 9-foot beam trawl, mud bag.

7757. August 21, 1905. (*a*) Falmouth Observatory-Nobska 68° 21′, Nobska-Nortons Point 78° 49′; (*b*) Falmouth Observatory-Nobska 65° 05′, Nobska-Nortons Point 80° 48′; (*c*) Falmouth Observatory-Nobska 63° 38′, Nobska-Nortons Point 85° 40′; 13 fathoms; stones and shells; 9-foot beam trawl, mud bag.

7758. August 21, 1905. (*a*) Falmouth Observatory-Nobska 62° 00′, Nobska-Nortons Point 69° 22′; (*b*) Falmouth Observatory-Nobska 60° 37′, Nobska-Nortons Point 67° 01′; (*c*) Falmouth Observatory-Nobska 58° 58′, Nobska-Nortons Point 66° 02′; 13 fathoms; stones and shells; 9-foot beam trawl, mud bag.

7759. August 21, 1905. (*a*) Falmouth Observatory-Nobska 53° 05′, Nobska-Nortons Point 61° 15′; (*b*) Nobska-West Chop 65° 36′, West Chop-East Chop 95° 40′; (*c*) Nobska-West Chop 55° 39′, West Chop-East Chop 105° 55′; 11½ fathoms; sand and stones; 9-foot beam trawl, mud bag.

7760. August 21, 1905. (*a*) Vineyard Haven Water Tower-West Chop 61° 28′, West Chop-East Chop 113° 11′; (*b*) Nobska-West Chop 30° 28′, West Chop-East Chop 110° 37′; (*c*) Nobska-West Chop 27° 73′, West Chop-East Chop 108° 32′; 8½ fathoms; pebbles and shells; 9-foot beam trawl, mud bag.

Station no.

7761. August 21, 1905. (*a*) Nobska-Vineyard Haven Water Tower 72° 56′, Vineyard Haven Water Tower-East Chop 86° 46′; (*b*) Nobska-Vineyard Haven Water Tower 74° 22′, Vineyard Haven Water Tower-East Chop 99° 42′; (*c*) Nobska-Vineyard Haven Water Tower 76° 52′, Vineyard Haven Water Tower-East Chop 111° 10′; 7 fathoms; sand and shells; 9-foot beam trawl, mud bag.

7762. August 21, 1905. (*a*) West Chop-Vineyard Haven Water Tower 78° 13′, Vineyard Haven Water Tower-East Chop 134° 50′; (*b*) East Chop-West Chop 139° 31′, West Chop-Vineyard Haven Water Tower 82° 23′; (*c*) East Chop-West Chop 121° 43′, West Chop-Vineyard Haven Water Tower 93° 83′; (*d*) East Chop-West Chop 114° 08′, West Chop-Vineyard Haven Water Tower 100° 04′; 4 fathoms; mud and shells; 9-foot beam trawl, mud bag.

7763. August 21, 1905. (*a*) Nobska-West Chop 61° 01′, West Chop-East Chop 72° 18′; (*b*) Nobska-West Chop 60° 24′, West Chop-East Chop 78° 03′; (*c*) Nobska-West Chop 59° 36′, West Chop-East Chop 82° 14′; 13 fathoms; shells and pebbles; 9-foot beam trawl, mud bag.

7764. August 21, 1905. (*a*) Nobska-West Chop 72° 31′, West Chop-East Chop 45° 55′; (*b*) Nobska-West Chop 72° 38′, West Chop-East Chop 48° 46′; (*c*) Nobska-West Chop 74° 19′, West Chop-East Chop 51° 10′; 6 fathoms; sand; 9-foot beam trawl, mud bag.

7765. August 21, 1905. (*a*) Nobska-West Chop 81° 10′, West Chop-East Chop 55° 59′; (*b*) Nobska-West Chop 80° 52′, West Chop-East Chop 59° 50′; (*c*) Nobska-West Chop 80° 41′, West Chop-East Chop 63° 48′; 13½ fathoms; rocky; 9-foot beam trawl, mud bag.

7766. August 21, 1905. (*a*) Nobska-West Chop 74° 03′, West Chop-East Chop 31° 41′; (*b*) Nobska-West Chop 75° 37′, West Chop-East Chop 32° 29′; (*c*) Nobska-West Chop 78° 12′, West Chop-East Chop 33° 03′; 5 fathoms; pebbles and sand; 9-foot beam trawl, mud bag.

7767. August 25, 1905. (*a*) Nobska-West Chop 76° 21′, West Chop-East Chop 36° 35′; (*b*) Nobska-West Chop 76° 31′, West Chop-East Chop 39° 23′; (*c*) Nobska-West Chop 76° 57′, West Chop-East Chop 41° 58′; 10 to 4 fathoms; sand and pebbles; 9-foot beam trawl and mud bag.

7768. August 23, 1905. (*a*) Nobska-West Chop 96° 45′, West Chop-East Chop 35° 47′; (*b*) Nobska-West Chop 100° 32′, West Chop-East Chop 36° 40′; (*c*) Nobska-West Chop 103° 29′, West Chop-East Chop 37° 13′; 10 fathoms; stones; 9-foot beam trawl, mud bag.

7769. August 23, 1905. (*a*) Nobska-West Chop 93° 20′, West Chop-East Chop 28° 25′; (*b*) Nobska-West Chop 95° 21′, West Chop-East Chop 28° 38′; (*c*) Nobska-West Chop 97° 19′, West Chop-East Chop 28° 27′; 7 fathoms; pebbles; 9-foot beam trawl, mud bag.

7770. August 23, 1905. (*a*) Nobska-West Chop 108° 34′, West Chop-East Chop 27° 53′; (*b*) Nobska-West Chop 112° 47′, West Chop-East Chop 28° 58′; (*c*) Nobska-West Chop 109° 45′, West Chop-East Chop 29° 52′; 10 to 12 fathoms; sand and pebbles; 9-foot beam trawl and mud bag.

7771. August 23, 1905. (*a*) Nobska-West Chop 102° 48′, West Chop-East Chop 20° 14′; (*b*) Nobska-West Chop 104° 40′, West Chop-East Chop 20° 12′; 7 fathoms; sand and rocks; 9-foot beam trawl and mud bag.

7772. August 23, 1905. (*a*) Nobska-West Chop 115° 34′, West Chop-East Chop 19° 19′; (*b*) Falmouth Water Tower-Nobska 59° 07′, Nobska-West Chop 118° 57′; (*c*) East Chop-Falmouth Observatory 115° 48′, Falmouth Observatory-Nobska 101° 04′; 6 to 8 fathoms; sand and pebbles; 9-foot beam trawl, mud bag.

7773. August 23, 1905. (*a*) East Chop-Falmouth Observatory 109° 41′, Falmouth Observatory-Nobska 92° 52′; (*b*) East Chop-Falmouth Observatory 106° 42′, Falmouth Observatory-Nobska 89° 15′, (*c*) East Chop-Falmouth Observatory 104° 46′, Falmouth Observatory-Nobska 87° 30′; 11½ fathoms; pebbles and stones; 9-foot beam trawl, mud bag.

7774. August 23, 1905. (*a*) Falmouth Water Tower-Nobska 80° 58′, Nobska-West Chop 113° 21′; (*b*) Falmouth Water Tower-Nobska 77° 05′, Nobska-West Chop 122° 19′; (*c*) Falmouth Water Tower-Nobska 73° 45′, Nobska-West Chop 130° 01′; 7½ fathoms; pebbles; 9-foot beam trawl, mud bag.

7775. August 23, 1905. (*a*) Falmouth Observatory-Nobska 108° 00′, Nobska-Nortons Point 87° 33′; (*b*) Falmouth Observatory-Nobska 102° 15′, Nobska-Nortons Point 93° 00′; (*c*) Falmouth Observatory-Nobska 96° 18′, Nobska-Nortons Point 98° 44′; 9 fathoms; pebbles and stones; 9-foot beam trawl, mud bag.

Station no.

7776. August 23, 1905. (*a*) Falmouth Water Tower-Nobska 121° 21′, Nobska-Nortons Point 43° 15′; (*b*) Falmouth Water Tower-Nobska 116° 56′, Nobska-Nortons Point 50° 36′; (*c*) Falmouth Water Tower-Nobska 111° 54′, Nobska-Nortons Point 58° 40′; (*d*) Falmouth Water Tower-Nobska 104° 14′, Nobska-Nortons Point 70° 45′; 5 to 7 fathoms; stones and shells; 9-foot beam trawl, mud bag.

7777. August 26, 1905. (*a*) Falmouth Water Tower-Nobska 49° 03′, Nobska-East Chop 92° 19′; (*b*) Falmouth Water Tower-Nobska 50° 32′, Nobska-East Chop 90° 11′; (*c*) Falmouth Water Tower-Nobska 53° 47′, Nobska-East Chop 90° 02′; 5½ fathoms; sand and pebbles; 9-foot beam trawl and mud bag.

7778. August 26, 1905. (*a*) Falmouth water tower-Nobska 59° 42′, Nobska-East Chop 88° 47′; (*b*) Falmouth water tower-Nobska 63° 32′, Nobska-East Chop 86° 55′; (*c*) Falmouth water tower-Nobska 66° 03′, Nobska-East Chop 85° 10′; 4 fathoms; sand and pebbles; 9-foot beam trawl and mud bag.

7779. August 26, 1905. (*a*) Falmouth water tower-Nobska 46° 29′, Nobska-East Chop 104° 21′; (*b*) Falmouth water tower-Nobska 50° 48′, Nobska-East Chop 105° 07′; (*c*) Falmouth water tower-Nobska 54° 52′, Nobska-East Chop 104° 08′; 12½ fathoms; sand; 9-foot beam trawl and mud bag.

7780. August 26, 1905. (*a*) Falmouth water tower-Nobska 64° 02′, Nobska-East Chop 101° 21′; (*b*) Falmouth water tower-Nobska 72° 52′, Nobska-East Chop 98° 08′; (*c*) Falmouth water tower-Nobska 80° 51′, Nobska-East Chop 95° 18′; 7½ fathoms; sand and pebbles; 9-foot beam trawl and mud bag.

7781. August 26, 1905. (*a*) Falmouth water tower-Nobska 95° 20′, Nobska-East Chop 91° 00′; (*b*) Falmouth water tower-Nobska 108° 03′, Nobska-East Chop 86° 46′; (*c*) Falmouth water tower-Nobska 121° 43′, Nobska-East Chop 82° 13′; 5 fathoms; coarse sand and pebbles; 9-foot beam trawl and mud bag.

7782. August 26, 1905. (*a*) Falmouth water tower-Nobska 60° 57′, Nobska-East Chop 112° 47′; (*b*) Falmouth water tower-Nobska 66° 59′, Nobska-East Chop 113° 11′; (*c*) Falmouth water tower-Nobska 75° 59′, Nobska-East Chop 111° 51′; 10 fathoms; sand and pebbles; 9-foot beam trawl, mud bag.

7783. August 26, 1905. (*a*) Falmouth water tower-Nobska 95° 53′, Nobska-East Chop 106° 36′; (*b*) Falmouth water tower-Nobska 105° 35′, Nobska-East Chop 103° 23′; (*c*) Falmouth water tower-Nobska 121° 58′, Nobska-East Chop 96° 42′, (*d*) Falmouth water tower-Nobska 136° 41′, Nobska-East Chop 88° 47′; (*e*) West Chop-Falmouth observatory 83° 28′, Falmouth observatory-Falmouth water tower 58° 12′; 5 fathoms; sand, pebbles, and shells; 9-foot beam trawl, mud bag.

The following Fish Hawk stations of 1903 were repeated with approximate accuracy by the Fish Hawk and Phalarope during the summer of 1904:

Station no.

7521bis. July 14, 1904. Nobska NE by E, ½ mile; 7½ fathoms; coarse stones and sand; 24-inch scrape dredge; drift SW ¼ mile.

7522bis. July 14, 1904. Nobska N ½ W, 1 mile; 14¾ fathoms; sand and gravel; 7-foot beam trawl; drift SW ¼ mile.

7523bis. July 14, 1904. Nobska NNW, 1⅝ miles; 12 fathoms; stones and coarse gravel; 7-foot beam trawl, 24-inch dredge; drift SW ¼ mile.

7524bis. July 14, 1904. Nobska NW by N ½ N, 2¼ miles; 10 fathoms; small stones; 7-foot beam trawl, 24-inch dredge; drift SW ¼ mile.

7525bis. July 14, 1904. Nobska NNW ¼ W, 2⅝ miles; 10 fathoms; sandy; 7-foot beam trawl, 24-inch scrape dredge, oyster dredge; drift SW ¼ mile.

7530bis. September 3, 1904. 12 fathoms; stones and shell fragments; scrape dredge.

7531bis. September 2, 1904. 8½ fathoms; gravel and small stones; scrape dredge.

7532bis. July 18, 1904. West Chop ESE, Tarpaulin Cove W by S ½ S; 9 fathoms; mud and gravel; rake dredge; drift SSW ½ mile.

7533bis. July 18, 1904. Tarpaulin Cove W by S, West Chop E by S ½ S; 15 fathoms; sand and gravel; rake dredge; drift S ½ mile.

Station no.

7534bis. July 18, 1904. Tarpaulin Cove W ½ S, West Chop E by S; Nobska NE; 12 fathoms; coarse gravel; trawl; drift SW ¼ mile.

7535bis. July 18, 1904. Nobska NNE, Tarpaulin Cove W by N ¾ N; 12 fathoms; stones and coarse gravel; beam trawl; drift SW ¼ mile.

7536bis. July 18, 1904. Nobska N by E ½ E, Tarpaulin Cove W by N ½ N; 11½ fathoms; coarse sand and shells; beam trawl, 22-inch scrape dredge; drift SW ½ mile.

7537bis. July 18, 1904. Tarpaulin Cove W by S ½ S, West Chop E by S ¼ S; 4½ fathoms; gravel and mud; rake dredge; drift SW by S ½ mile.

7538bis. September 6, 1904. 11 fathoms; scrape dredge.

7539bis. September 3, 1904. 12½ to 12 fathoms; gravel and stones; scrape dredge. (Very scanty haul.)

7541bis. September 7, 1904. 11½ fathoms; gravel and stones; scrape dredge.

7542bis. September 7, 1904. 7½ fathoms; sandy; scrape dredge.

7543bis. July 20, 1904. Gay Head SW ½ S, Nobska E by N ½ N; 13 fathoms; sandy (?); 7-foot beam trawl; drift NE ⅛ mile.

7544bis. July 20, 1904. Tarpaulin Cove W ¾ N, Nobska NE by E ½ E; 13 fathoms; rake dredge; drift NE ¼ mile.

7545bis. July 20, 1904. Nobska NE ½ E, Tarpaulin Cove NW by W ¾ W; 12½ fathoms; sand and gravel; 24-inch scrape dredge; drift NE ¼ mile.

7546bis. July 20, 1904. Nobska NE ½ E, Tarpaulin Cove NW by W ½ W; 10 fathoms; shell fragments; oyster dredge; drift NE ¼ mile.

7547bis. July 20, 1904. Nobska NE ¾ N, Tarpaulin Cove NW ¾ W; 13 fathoms; sand, coarse gravel, and shell fragments; 7-foot beam trawl, oyster dredge, scrape dredge; drift NE ½ E ¼ mile.

7549bis. September 6, 1904. 12 fathoms; small stones; scrape dredge.

7550bis. September 6, 1904. 17 fathoms; stony; scrape dredge.

7551bis. September 6, 1904. 11 fathoms; small stones and mussel shells; scrape dredge.

7552bis. September 7, 1904. 12 fathoms; sand; scrape dredge.

7553bis. September 7, 1904. 8 fathoms; scrape dredge.

7554bis. September 7, 1904. 12 fathoms; mud (?) and sand; scrape dredge.

7556bis. September 7, 1904. 5½ fathoms; coarse sand; scrape dredge.

7562bis. September 10, 1904. 4½ fathoms; sand; scrape dredge.

7563bis. September 10, 1904. 7 fathoms; coarse sand; scrape dredge.

7564bis. September 10, 1904. 12 fathoms; muddy sand and gravel; scrape dredge.

7565bis. September 10, 1904. 15 fathoms; sandy; scrape dredge.

7569bis. September 10, 1904. 5½ fathoms; fine sand; scrape dredge.

PHALAROPE STATIONS.[a]

1. July 6, 1904. Vineyard Sound south shore of Nonamesset Island; 4½ fathoms; gravel; 22-inch dredge.
2. July 6, 1904. Vineyard Sound, south shore of Nonamesset Island; 6½ fathoms; sand and gravel; 22-inch dredge.
3. July 6, 1904. Vineyard Sound, south shore of Nonamesset Island; 5¼ fathoms; sandy; 22-inch dredge.
4. July 6, 1904. Vineyard Sound, south shore of Nonamesset Island; 2 to 5 fathoms; sandy; 22-inch dredge. (Scanty haul.)
5. July 8, 1904. Vineyard Sound, south shore of Naushon Island; 8 to 10 fathoms, stony; 22-inch dredge.
6. July 8, 1904. Vineyard Sound, south shore of Naushon Island; 10 to 9 fathoms; stony and gravelly; 22-inch dredge.
7. July 8, 1904. Vineyard Sound, south shore of Naushon Island; 6½ fathoms; stones and gravel; 22-inch dredge.
8. July 13, 1904. 5 to 4½ fathoms; soft mud, hard mud; 22-inch dredge.
9. July 13, 1904. 5½ to 8 fathoms; hard sand; 22-inch dredge.

[a] Including also Blue Wing stations, as indicated.

10. July 13, 1904. 10 to 14 fathoms; hard sand, sand and gravel; 22-inch dredge.
11. July 13, 1904. 10 to 9 fathoms; hard sand, sand and rock; 22-inch dredge.
12. July 13, 1904. 13 fathoms; hard sand; 22-inch dredge.
13. July 15, 1904. Vineyard Sound, shore of Naushon; 12 to 12½ fathoms; gravel, gravel and sand; 22-inch dredge.
14. July 15, 1904. Vineyard Sound, shore of Naushon; 5 to 6 fathoms; stones and sand, stone; 22-inch dredge.
15. July 15, 1904. Vineyard Sound, shore of Naushon; 7½ to 7½ fathoms; stones; 22-inch dredge.
16. July 15, 1904. Vineyard Sound, shore of Naushon; 4 to 5 fathoms; stones and sand; 22-inch dredge.
17. July 19, 1904. Tarpaulin Cove; 2¼ to 4 fathoms; sand and gravel; oyster dredge.
18. July 19, 1904. Tarpaulin Cove; 2½ to 2¾ fathoms; soft mud and eelgrass; oyster dredge and 22-inch dredge.
19. July 19, 1904. Tarpaulin Cove; 4 to 3 fathoms; mud, sand; 22-inch dredge.
20 (Blue Wing). July 23, 1904. Robinsons Hole; 2½ to 2 fathoms; stony with many algæ.
21 (Blue Wing). July 23, 1904. Robinsons Hole; 3 to 1½ fathoms; rocky with many algæ.
22 (Blue Wing). July 23, 1904. Robinsons Hole; 3½ fathoms; gravel.
23 (Blue Wing). July 23, 1904. Robinsons Hole; 2½ fathoms; sandy.
24. July 26, 1904. South side of Pasque Island; 5 to 5½ fathoms; hard sand.
25. July 26, 1904. South side of Pasque Island; 5 to 5 fathoms; hard, rocky.
26. July 26, 1904. South side of Pasque Island; 6 to 6½ fathoms; partly soft mud.
27. July 28, 1904. Quicks Hole; 4 to 5 fathoms; stony.
28. July 28, 1904. Quicks Hole; 5 fathoms; muddy sand.
29. July 28, 1904. Quicks Hole; 3 fathoms; sand.
30. July 28, 1904. South side of Nashawena; 4 to 5 fathoms; stony, sandy.
31. July 28, 1904. South side of Nashawena; 4 to 4½ fathoms; hard, clean sand.
32. July 30, 1904. South shore of Cuttyhunk Island; 5 to 5½ fathoms; stony.
33. July 30, 1904. South shore of Cuttyhunk Island; 5 to 5¼ fathoms; gravel and hard mud.
34. July 30, 1904. South shore of Cuttyhunk Island; 5½ to 6 fathoms; sandy.
35. August 3, 1904. Off Sow and Pigs Reef; 10 to 9 fathoms; stones.
36. August 3, 1904. Off Sow and Pigs Reef; 6½ to 9 fathoms; stony.
37. August 3, 1904. Off Sow and Pigs Reef; 4½ to 5 fathoms; stones, sand.
38. August 3, 1904. Off Sow and Pigs Reef; 4½ fathoms; stony.
39. August 4, 1904. Middle Ground; 7 to 3½ fathoms; clean sand.
40. August 4, 1904. Middle Ground; 6 to 5 fathoms; sand and broken shells.
41. August 4, 1904. Middle Ground; 2 to 4½ fathoms; sand and broken shells.
42. August 4, 1904. Middle Ground; 3½ to 6 fathoms; sand and broken shells.
43. August 4, 1904. Middle Ground; 2½ to 5 fathoms; sand and broken shells.
44 (Blue Wing). August 9, 1904. Near Gay Head; 3¼ to 5 fathoms; stony, hard sand; 22-inch scrape dredge.
45 (Blue Wing). August 9, 1904. Near Gay Head; 5 fathoms; stony; 22-inch scrape dredge.
46 (Blue Wing). August 9, 1904. Near Gay Head; 10 feet to 3½ fathoms; hard sand; 22-inch scrape dredge and tangle.
47 (Blue Wing). August 9, 1904. Near Gay Head; 8 to 12 feet; rock, sand; 22-inch scrape dredge and tangle.
48 (Blue Wing). August 9, 1904. Near Gay Head; sand; 22-inch scrape dredge.
49 (Blue Wing). August 9, 1904, Near Gay Head; sand; 22-inch scrape dredge.
50 (Blue Wing). August 9, 1904. Near Gay Head; sand; 22-inch scrape dredge.
51. August 9, 1904. This includes several hauls, about alike in character, done with 16-inch scrape dredge, operated from a skiff close to shore; 1 to 1½ fathoms; sand. Collections were also made from stones and from piles, between tides.
52. August 11, 1904. 7 to 6½ fathoms; shelly and gravelly.
53. August 11, 1904. 5½ to 5½ fathoms; shelly and sandy.
54. August 11, 1904. 5½ to 7 fathoms, hard, clean sand.

55 August 11, 1904. 7½ to 8½ fathoms; clean sand.
56. August 15, 1904. Near Gay Head; 7 to 7½ fathoms; gravel and sand.
57. August 15, 1904. Near Gay Head; 5 to 9 fathoms; sand and gravel.
58. August 15, 1904. Near Gay Head; 6½ to 9½ fathoms; sand and gravel.
59. August 15, 1904. Near Gay Head; 11 to 12 fathoms; shell bottom.
60. August 15, 1904. Near Gay Head; 8½ to 6 fathoms; sand and shells.
61. August 19, 1904. 5¼ to 5 fathoms; clean sand.
62. August 19, 1904. 7 to 7 fathoms; sandy and pebbly.
63. August 19, 1904. 7 to 6½ fathoms; sandy and pebbly.
64. August 24, 1904. 6½ to 6 fathoms; hard sand.
65. August 24, 1904. 6 to 3½ fathoms; gravel.
66. August 24, 1904. 6 to 7½ fathoms; sandy.
67. August 24, 1904. 4½ to 3½ fathoms; sandy.
68. August 24, 1904. 6½ to 8 fathoms; sandy and shelly.
69. August 26, 1904. Vineyard Haven; 3½ to 11½ fathoms: rock and stones; 22-inch scrape dredge.
70. August 26, 1904. Vineyard Haven; 4 to 4 fathoms; shelly mud; 22-inch scrape dredge.
71. August 26, 1904. Vineyard Haven; 3½ to 3½ fathoms; shells and mud; oyster dredge.
72. August 26, 1904. Vineyard Haven; 3 to 4 fathoms; shells and mud; oyster dredge.
73. August 30, 1904. 5 to 2½ fathoms; mud; scrape dredge.
74. August 30, 1904. 5½ to 6 fathoms; sandy; scrape dredge.
75. August 30, 1904. 5¼ to 5¼ fathoms; sandy and eelgrass; scrape dredge.
76. August 30, 1904. 7 to 8½ fathoms; sandy; scrape dredge.
77. August 30, 1904. 4½ to 7 fathoms; gravelly; scrape dredge.
78. July 6, 1905. North shore of Nashawena, at western end; 6 to 5 fathoms; sand and mud.
79. July 6, 1905. North shore of Nashawena; 5½ to 5½ fathoms; mud.
80. July 6, 1905. North shore of Nashawena; 6 to 5 fathoms; sandy.
81. July 6, 1905. Buzzards Bay, near Quicks Hole; 7 to 7 fathoms; sandy.
82. July 6, 1905. Shore of Pasque Island near Quicks Hole; 8 to 8½ fathoms; sandy.
83. July 12, 1905. North shore of Pasque Island; 5 to 7 fathoms, sand.
84. July 12, 1905. North shore of Pasque Island; 6½ to 7½ fathoms; shells and mud.
85. July 12, 1905. Robinsons Hole; 5 to 6 fathoms; sand and shells.
86. July 12, 1905. West end of Naushon; 5 to 6 fathoms; sand,
87. July 15, 1905. Northwest shore of Naushon; 3¾ to 3 fathoms; algæ, stony.
88. July 15, 1905. Northwest shore of Naushon; 3½ fathoms; clean sand.
89. July 15, 1905. Northwest shore of Naushon; 3½ to 5 fathoms; muddy sand.
90. July 15, 1905. Northwest shore of Naushon; 4½ to 4¾ fathoms; clean sand.
91. July 15, 1905. Northwest shore of Naushon; 3¼ to 3 fathoms; clean gravel.
92. July 15, 1905. Northwest shore of Naushon; 4¾ to 5 fathoms; sand.
93. July 15, 1905. Northwest shore of Naushon; 7 to 8 fathoms; sandy mud.
94. July 18, 1905. Northwest shore of Naushon Island; 2 to 6½ fathoms; sandy mud.
95. July 18, 1905. Northwest shore of Naushon Island; 4 fathoms; mud and sand.
96. July 18, 1905. Northwestern extremity of Naushon Island; 4 to 3½ fathoms; clean, coarse sand.
97. July 18, 1905. 4¼ to 3¾ fathoms; coarse muddy gravel.
98. July 18, 1905. West end of Uncatena Island; 4 to 3¾ fathoms; muddy sand.
99. July 20, 1905. Near western end of Cuttyhunk Island; 3 to 3½ fathoms; sand.
100. July 20, 1905. Northwest shore of Cuttyhunk Island; 4 to 5 fathoms; sandy mud.
101. July 20, 1905. Northwest shore of Cuttyhunk Island, 4 to 4½ fathoms; clean sand.
102. July 20, 1905. Northwest shore of Cuttyhunk Island; 5 to 5 fathoms; loose sand.
103. July 20, 1905. North shore of Cuttyhunk Island; 4 to 5½ fathoms; clean sand.
104. July 20, 1905. Cuttyhunk Harbor; 2¾ to 3 fathoms; sand.
105. July 22, 1905. Near Weepecket Islands; 6 to 6½ fathoms; clean sand.
106. July 22, 1905. Near Weepecket Islands; 6 to 6 fathoms, clean sand.
107. July 22, 1905. Near Weepecket Islands; 5¼ to 5½ fathoms; mud and shells.
108. July 22, 1905. Near Weepecket Islands; 4½ to 5 fathoms; sand and gravel.

109. July 22, 1905. Near Weepecket Islands; 6¾ to 7¼ fathoms; clean sand.
110. July 22, 1905. Near Weepecket Islands; 5¼ to 7½ fathoms; muddy gravel.
111. July 25, 1905. Sow and Pigs Reef; 2½ to 7 fathoms; stones and pebbles; scrape dredge.
112. July 25, 1905. Western end of Cuttyhunk Island; 5 to 6 fathoms; stones; scrape dredge.
113. July 25, 1905. Near Penikese Island; 7 to 8 fathoms; sand and gravel; scrape dredge.
114. July 25, 1905. Near Penikese Island; 7 to 7½ fathoms; sand; scrape dredge.
115. July 25, 1905. Near Penikese Island; 5 to 7 fathoms; sand and gravel; scrape dredge.
116. July 25, 1905. Near Penikese Island; 3½ to 4 fathoms; pebbles and sand; scrape dredge.
117. July 27, 1905. North shore of Uncatena Island; 3 to 4½ fathoms; pebbles and stones.
118. July 27, 1905. East of Uncatena Island; 7 to 5 fathoms; sand and shells.
119. July 27, 1905. Hadley Harbor; 3 to 4 fathoms; mud and sand.
120. July 27, 1905. Entrance to Hadley Harbor; 5 to 4½ fathoms; sand and mud.
121. July 27, 1905. Woods Hole passage; 4 to 4¾ fathoms; sand and stones.
122. July 29, 1905. Near tip of Penzance Point; 4 to 5 fathoms, sand and gravel.
123. July 29, 1905. Near Penzance Point; 3 to 4 fathoms; sand and gravel.
124. July 29, 1905. North of Penzance Point; 4 to 4¾ fathoms; fine sand and stones.
125. July 29, 1905. Bay shore, near bathing beach; 3 to 4¾ fathoms; clean sand.
126. July 29, 1905. Near entrance to Quisset Harbor; 4 to 4¾ fathoms; shells and mud.
127. August 3, 1905. Quisset Harbor; 3 to 1¾ fathoms; black mud.
128. August 3, 1905. Near entrance of Quisset Harbor; 4 to 5 fathoms; rocks and gravel.
129. August 3, 1905. North of Quisset Harbor; 3 to 4½ fathoms; clean sand.
130. August 3, 1905. Near Gunning Point; 3¼ to 5 fathoms; sand and gravel.
131. August 3, 1905. Near Hamlin Point; 2½ to 3¼ fathoms; stones and sand.
132. August 5, 1905. East shore, Buzzards Bay; 4½ to 5 fathoms; sand and gravel.
133. August 5, 1905. South of Hog Island Harbor; 5¼ to 6 fathoms; sand and gravel.
134. August 5, 1905. Near entrance of Hog Island Harbor; 3¼ to 4¾ fathoms; stones and many algæ.
135. August 5, 1905. Entrance of Hog Island Harbor; 3¾ to 5 fathoms; sand and pebbles.
136. August 5, 1905. North of Hog Island Harbor; 3¾ to 4¼ fathoms; sand.
137. August 5, 1905. Between Hog Island Harbor and Wild Harbor; 4 to 4¾ fathoms; stones and sand.
138. August 7, 1905. South of Wild Harbor; 5¼ to 6½ fathoms; clean fine sand.
139. August 7, 1905. Wild Harbor; 7 to 5½ fathoms; clean sand.
140. August 7, 1905. Nyes Neck; 5 to 7½ fathoms; sand and shells.
141. August 7, 1905. Cataumet Harbor; 3 to 4 fathoms; sand and gravel.
142. August 7, 1905. Cataumet Harbor; 3 to 5¾ fathoms; pebbles and stones.
143. August 7, 1905. Cataumet Harbor; 4 to 6½ fathoms; mud.
144. August 9, 1905. Off Scraggy Neck; 4¾ to 4¾ fathoms; sand and shells.
145. August 9, 1905. Shore of Scraggy Neck; 4¼ to 3½ fathoms; sand and shells.
146. August 9, 1905. Between Scraggy Neck and Wenaumet Neck; 3 to 4 fathoms; fine sand.
147. August 9, 1905. Near Wings Neck Light; 3¼ to 3¼ fathoms; fine gravel.
148. August 9, 1905. Off Wings Neck Light; 4 to 4 fathoms; sand and shells.
149. August 9, 1905. North shore of Wenaumet Neck; 5 to 3¼ fathoms; sand and shells.
150. August 11, 1905. North shore of Wenaumet Neck; 4¾ to 2 fathoms; fine sand.
151. August 11, 1905. North shore of Wenaumet Neck; 2¾ to 1¼ fathoms; muddy sand.
152. August 11, 1905. Near head of Buzzards Bay; 2 to 2¾ fathoms; fine sandy mud.
153. August 11, 1905. Off Monument Beach; 2 to 2¾ fathoms; fine muddy sand.
154. September 6, 1905. Mouth of Weweantic River; 12 feet; soft black mud.
155. September 6, 1905. Wareham River; 14 feet; soft black mud.
156. September 6, 1905. Wareham River; 15 feet; soft black mud.
157. September 6, 1905. Wareham River; 15 feet; soft black mud.
158. September 6, 1905. Wareham River; 15 feet; shells.
159. August 27, 1907. Off Sippican Neck; 3½ fathoms; black sticky mud, few shells; 22-inch dredge; 15 minutes.
160. August 27, 1907. Aucoot Cove; 4 fathoms; fine sandy mud; 22-inch dredge; 15 minutes.

161. August 27, 1907. Mattapoisett Harbor; 3 fathoms; black mud; 22-inch dredge; repeated with "scollop dredge." (Scanty haul.)

162. August 27, 1907. West shore of West Island; 5 to 5½ fathoms; mud, slightly sandy, and a little fine gravel; 22-inch dredge; 15 minutes.

163. August 27, 1907. End of Sconticut Neck; 4 to 3½ fathoms; sandy mud and stones; 22-inch dredge and "scollop dredge."

164. August 27, 1907. Below New Bedford Harbor; 3 to 2¾ fathoms; black mud with a little sand, few stones, and shell fragments; 22-inch dredge; 20 minutes.

165. August 27, 1907. Entrance of Clark Cove; 3 fathoms; mud, shell fragments, and stones; 22-inch dredge.

166. August 27, 1907. Round Hill Point; 3 fathoms; black mud and shells; 22-inch dredge.

167. August 27, 1907. Mishaum Point; 3⅔ fathoms; shells and gravel; 22-inch dredge.

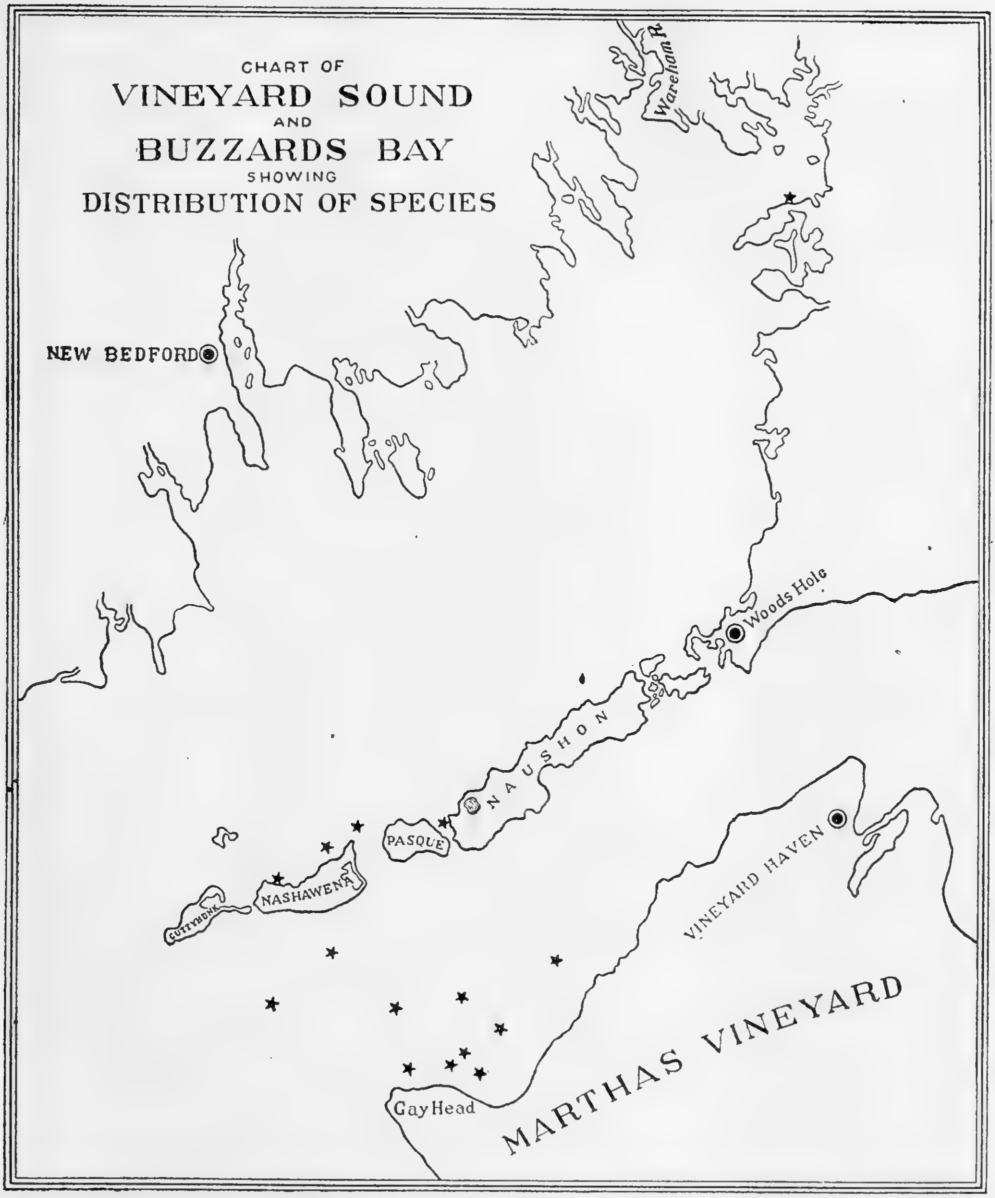

CHART 1.—Biloculina ringens.

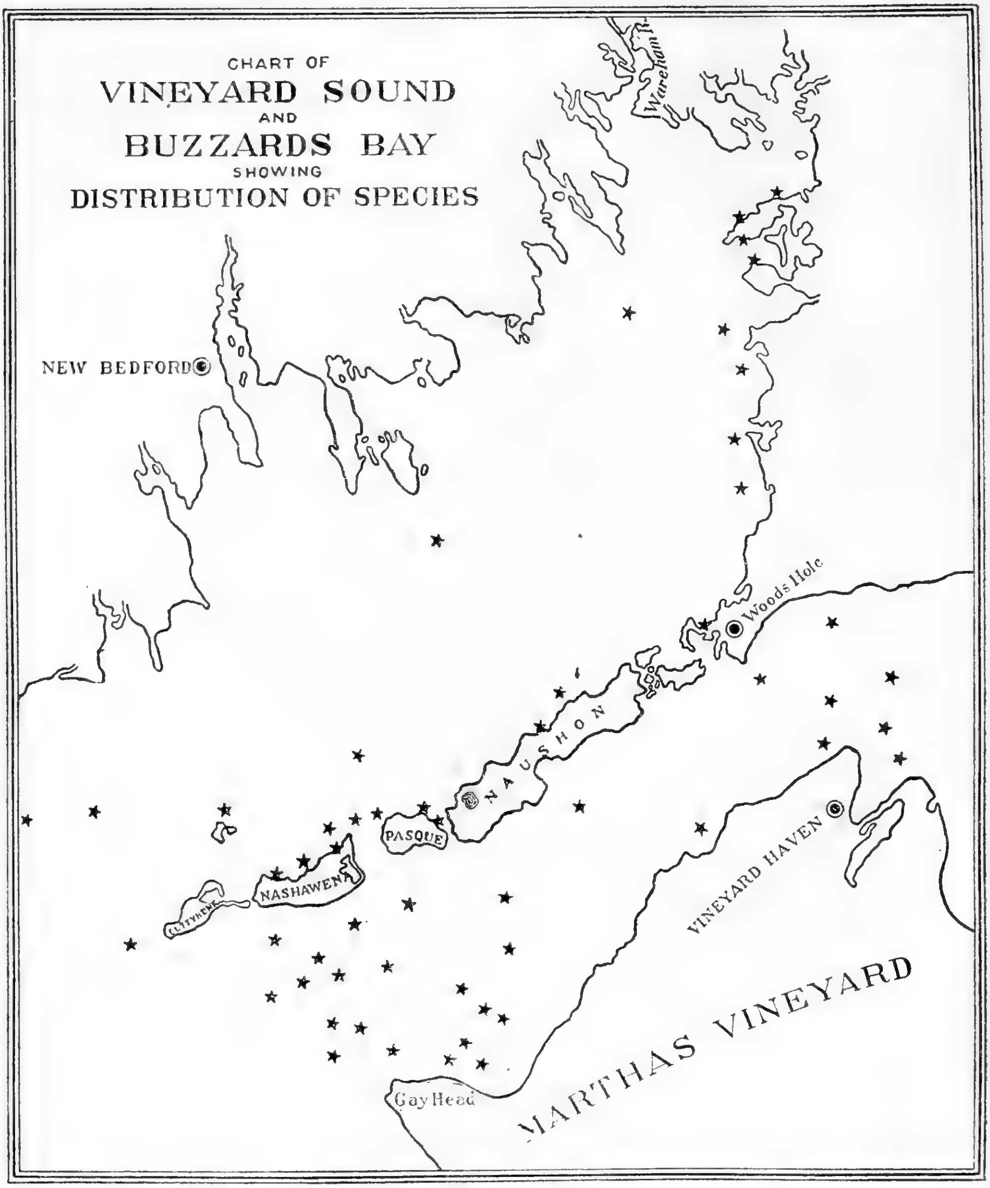

CHART 2.—Miliolina seminulum.

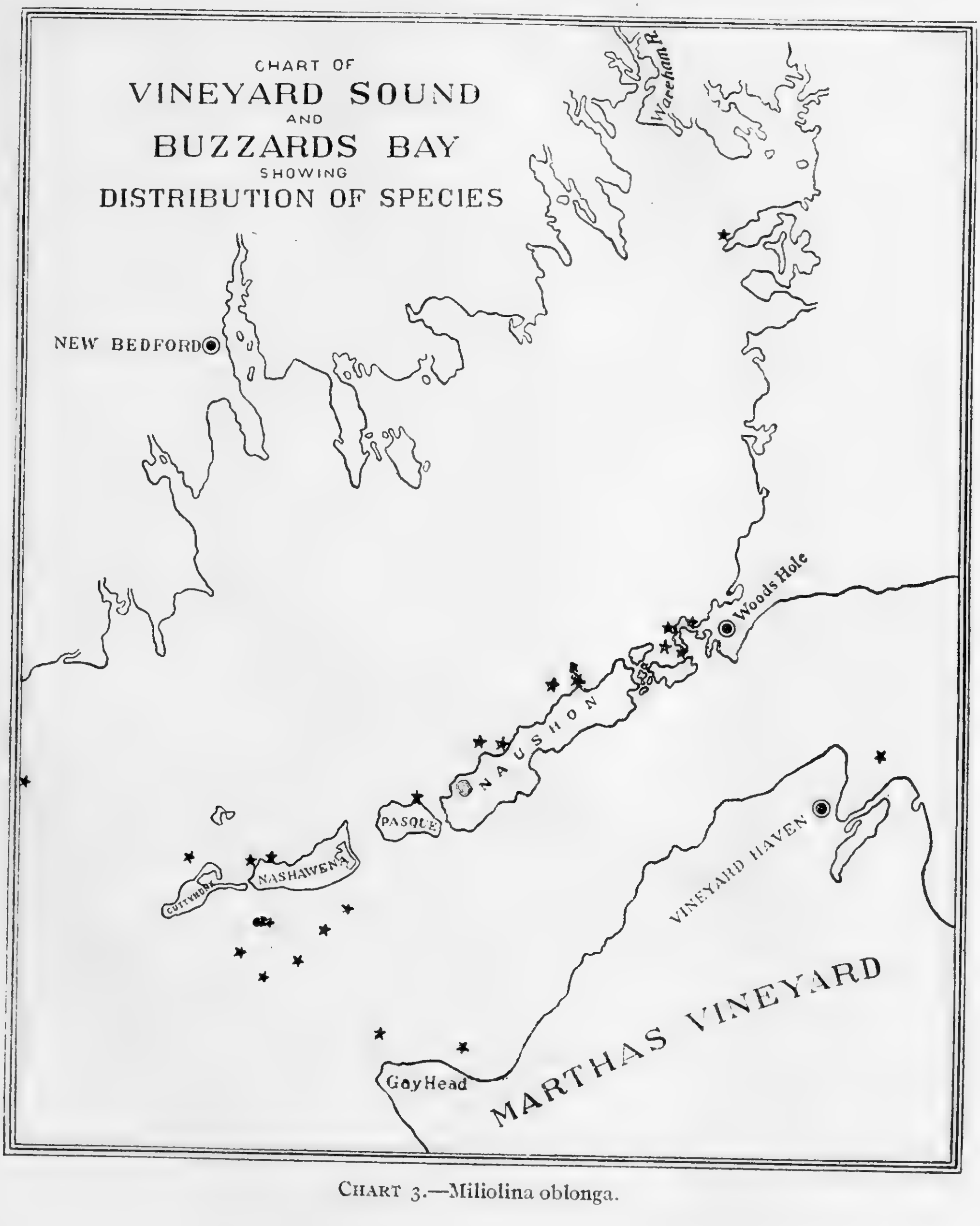

CHART 3.—Miliolina oblonga.

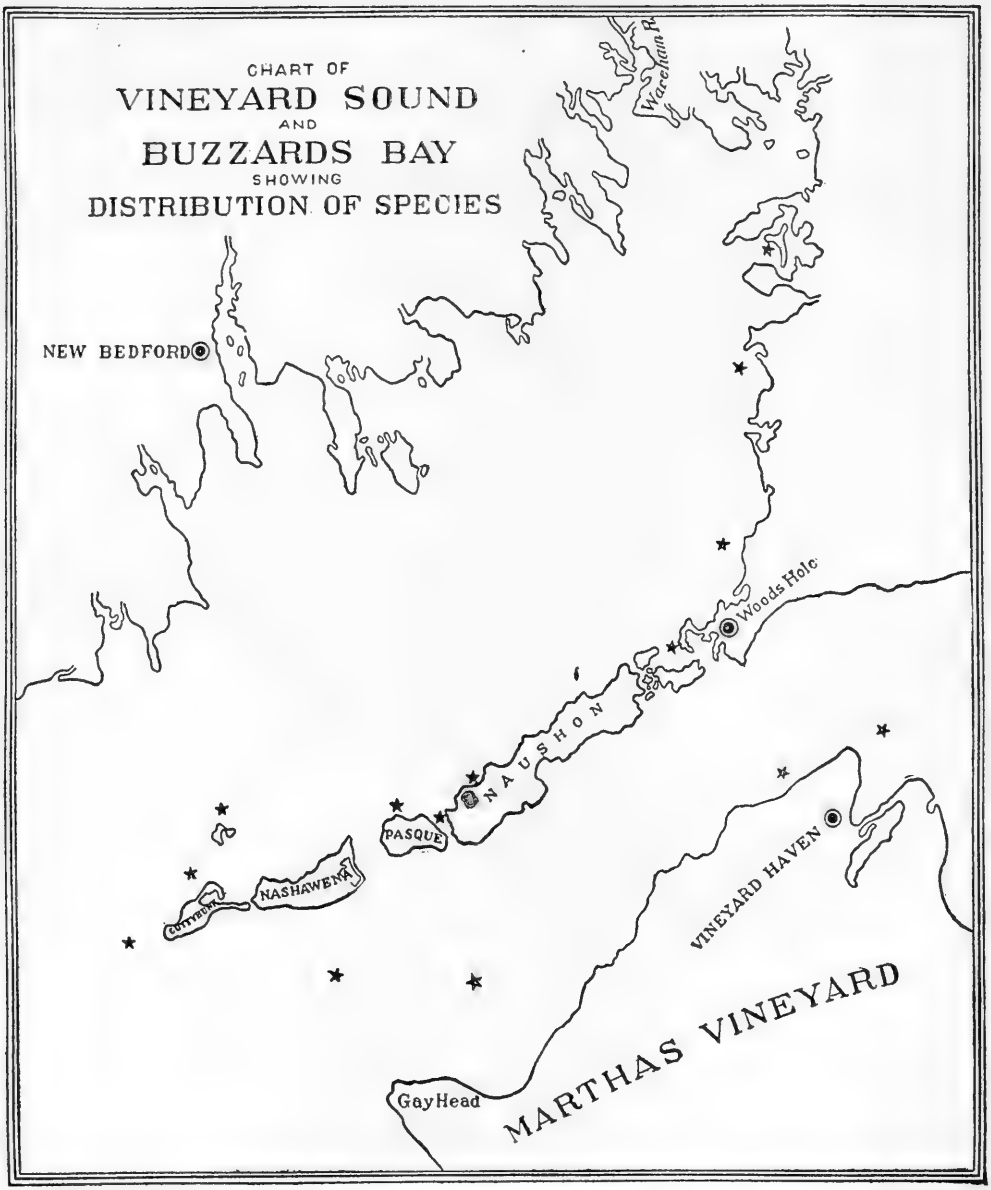

CHART 4.—Miliolina circularis.

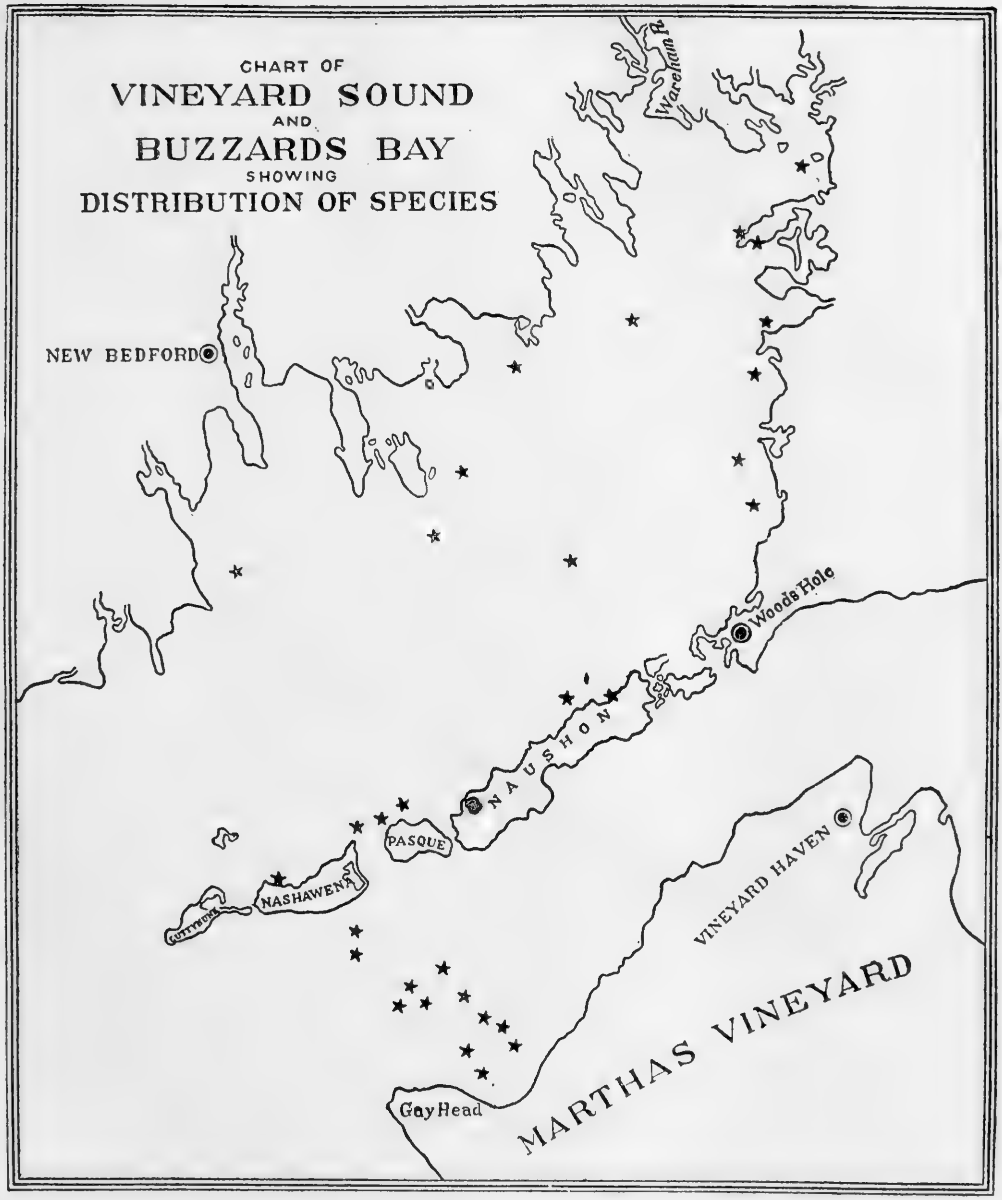

CHART 5.—Polymorphina lactea.

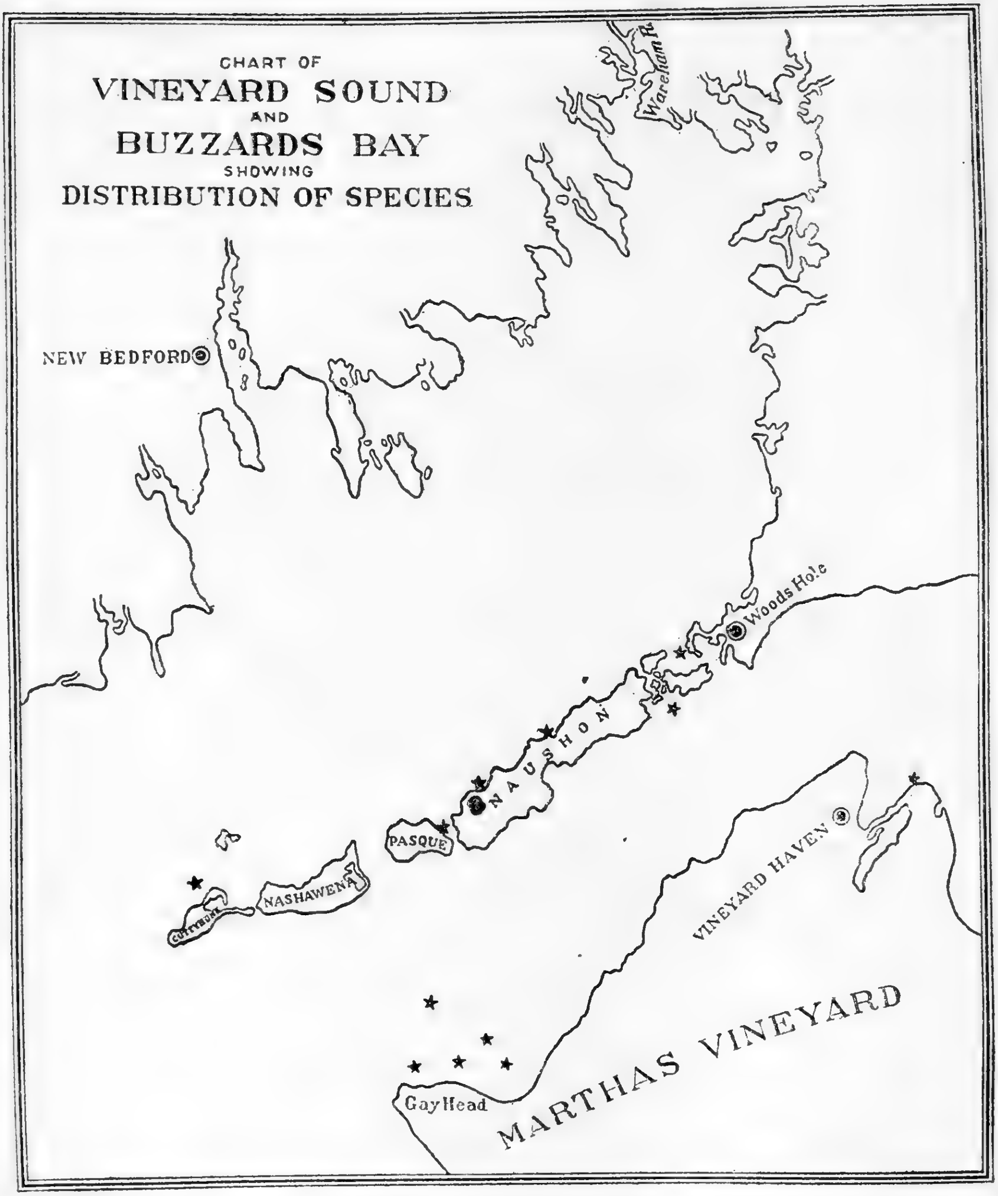

CHART 6.—Discorbina rosacea.

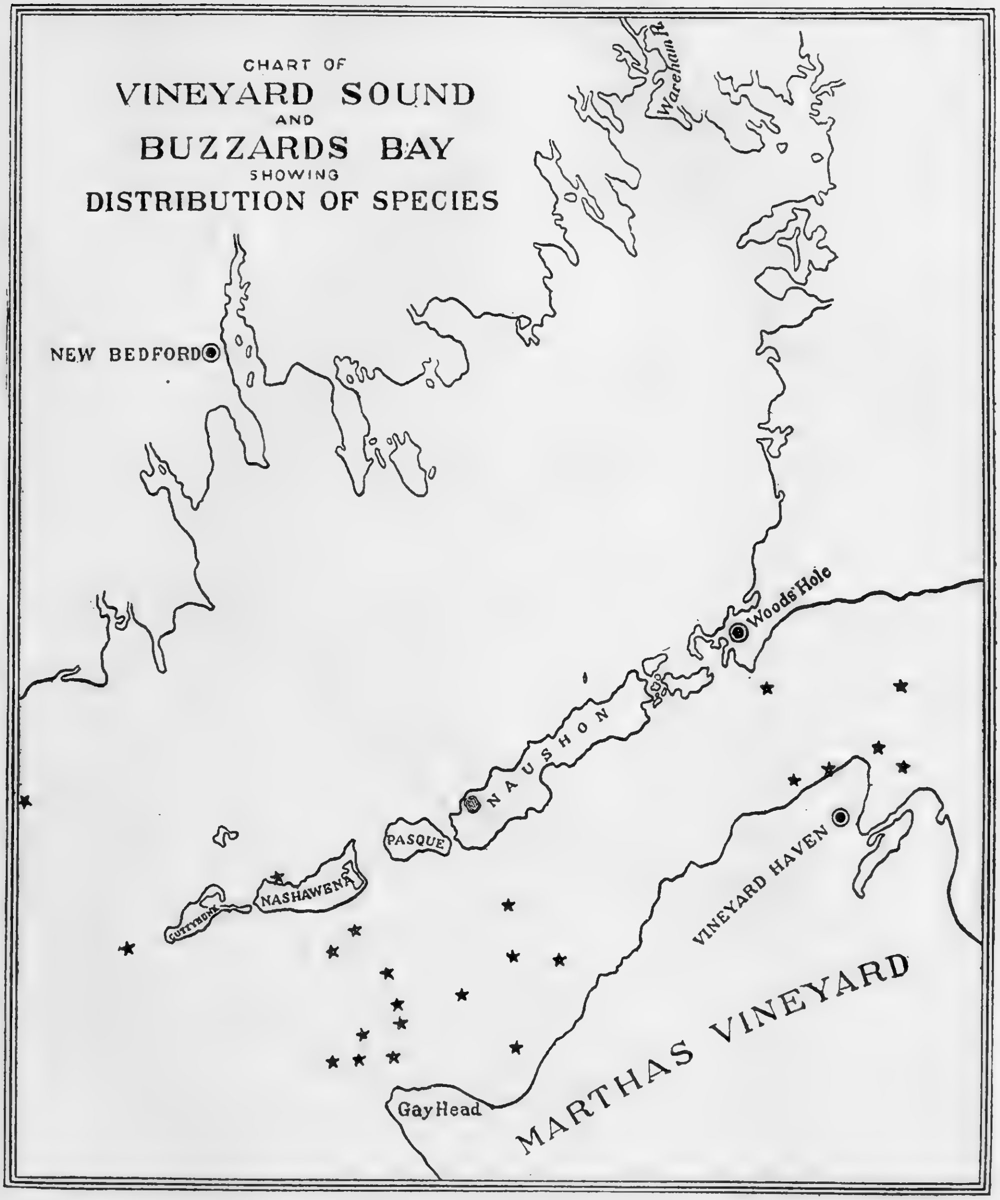

CHART 7.—Pulvinulina lateralis.

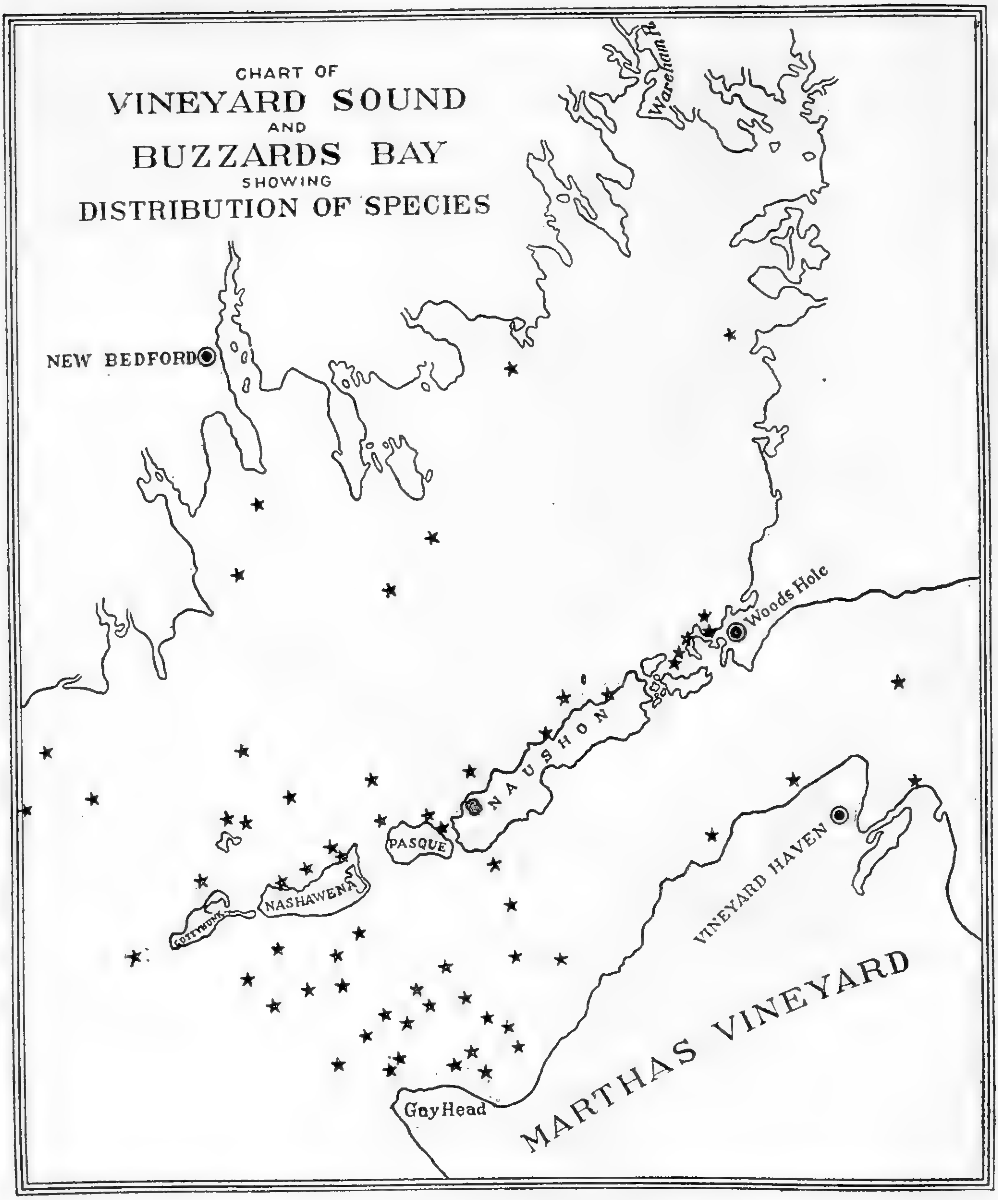

CHART 8.—Rotalia beccarii.

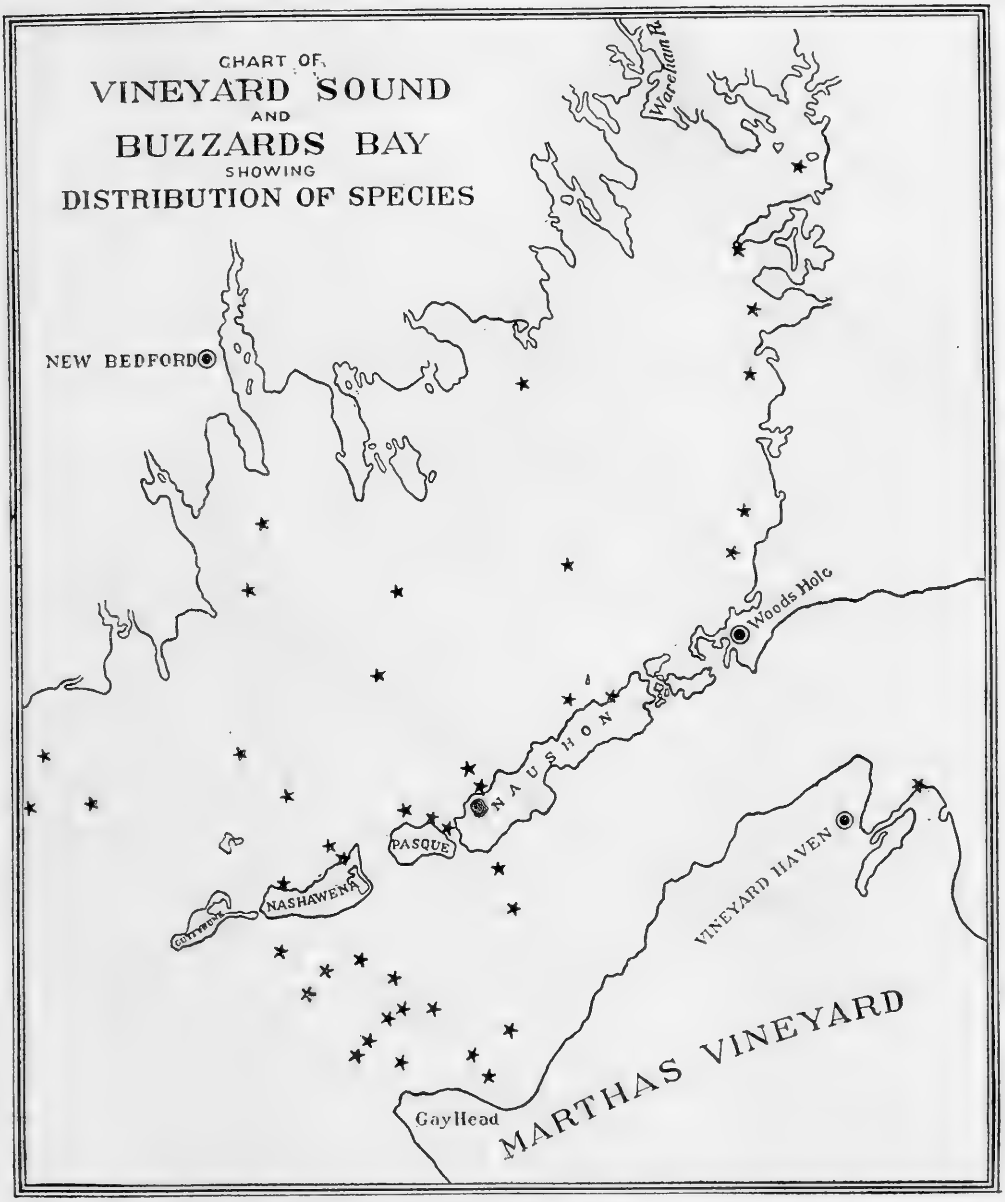

CHART 9.—Polystomella striatopunctata.

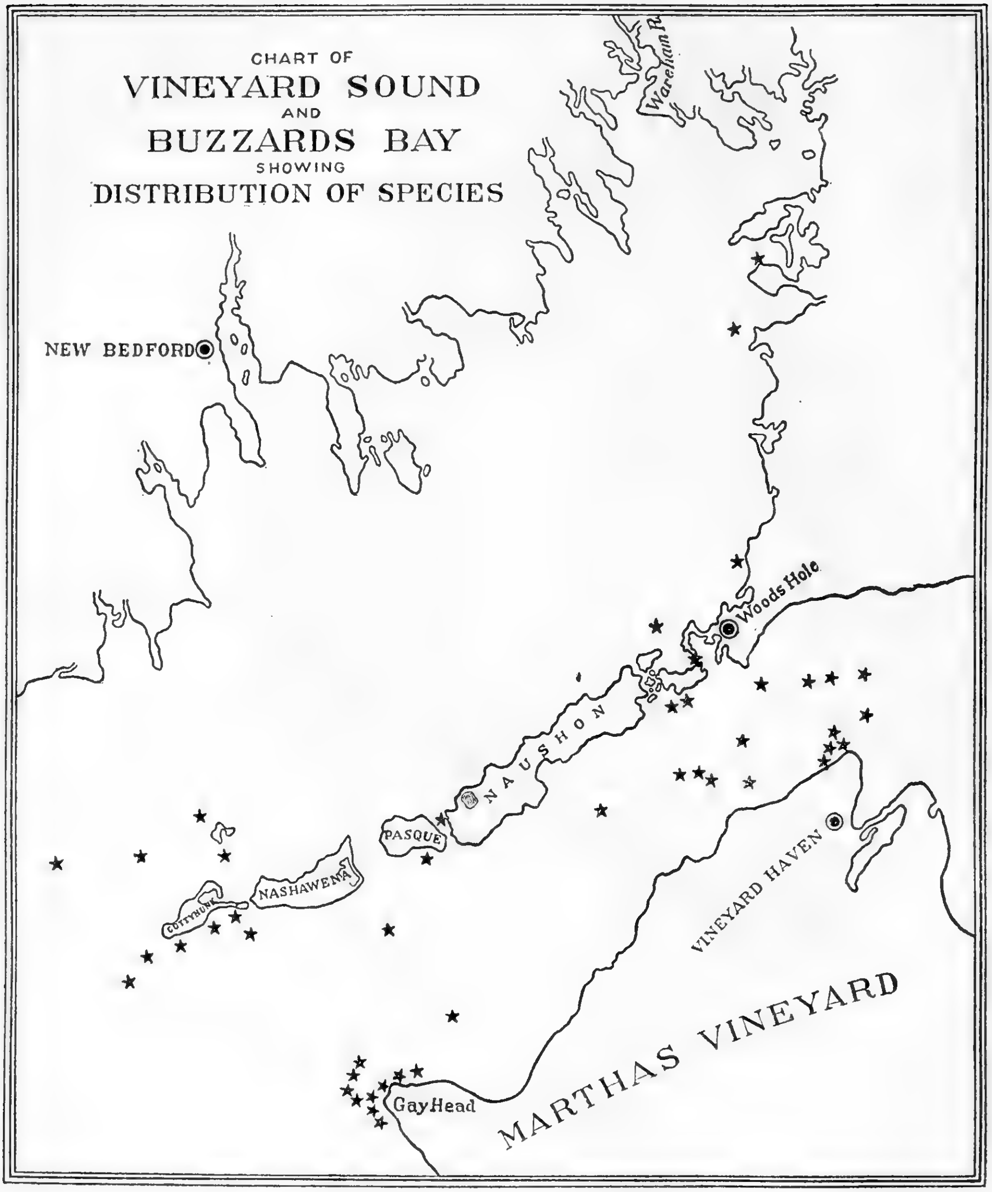

CHART 10.—Grantia ciliata?

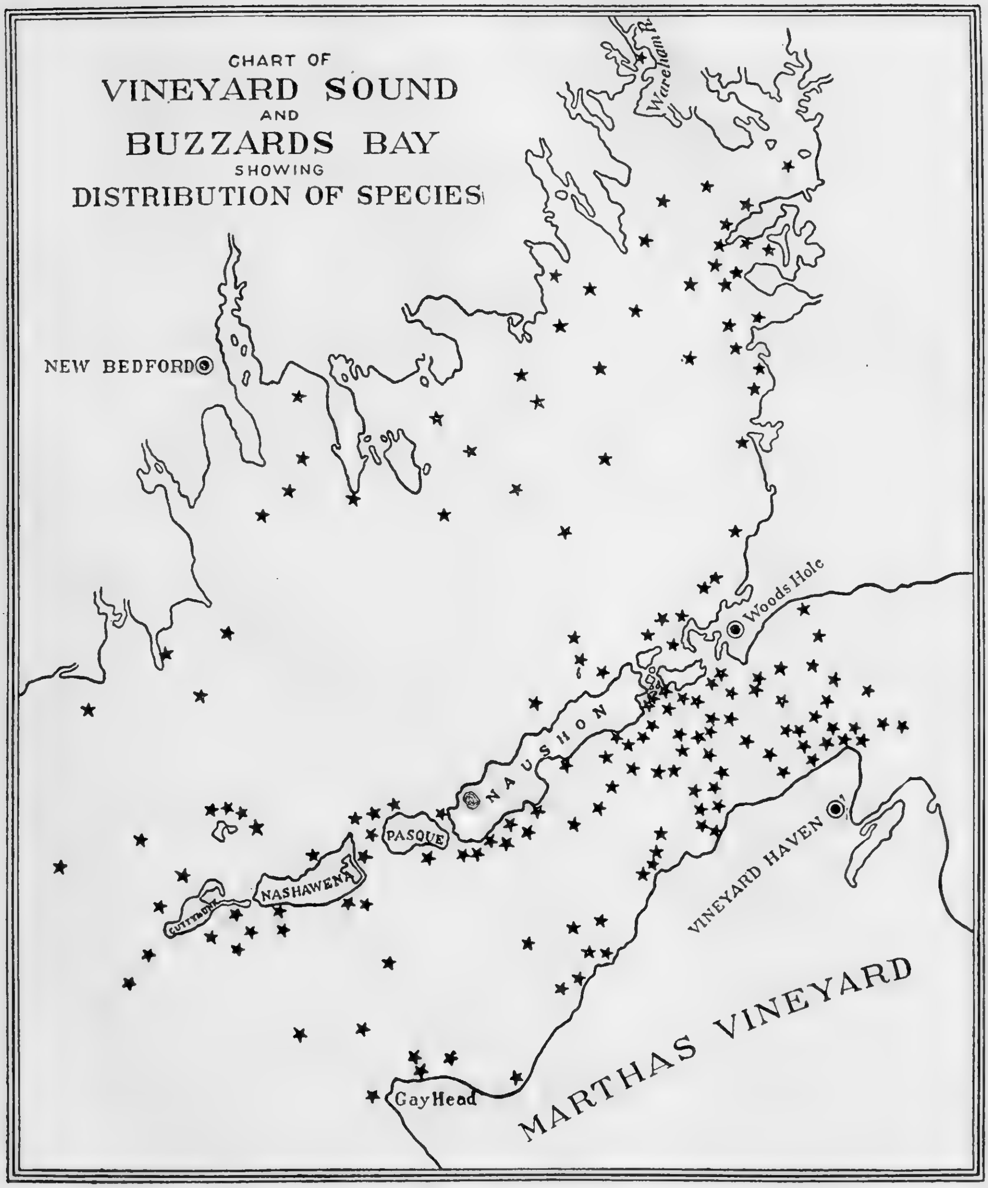

CHART 11.—Cliona celata.

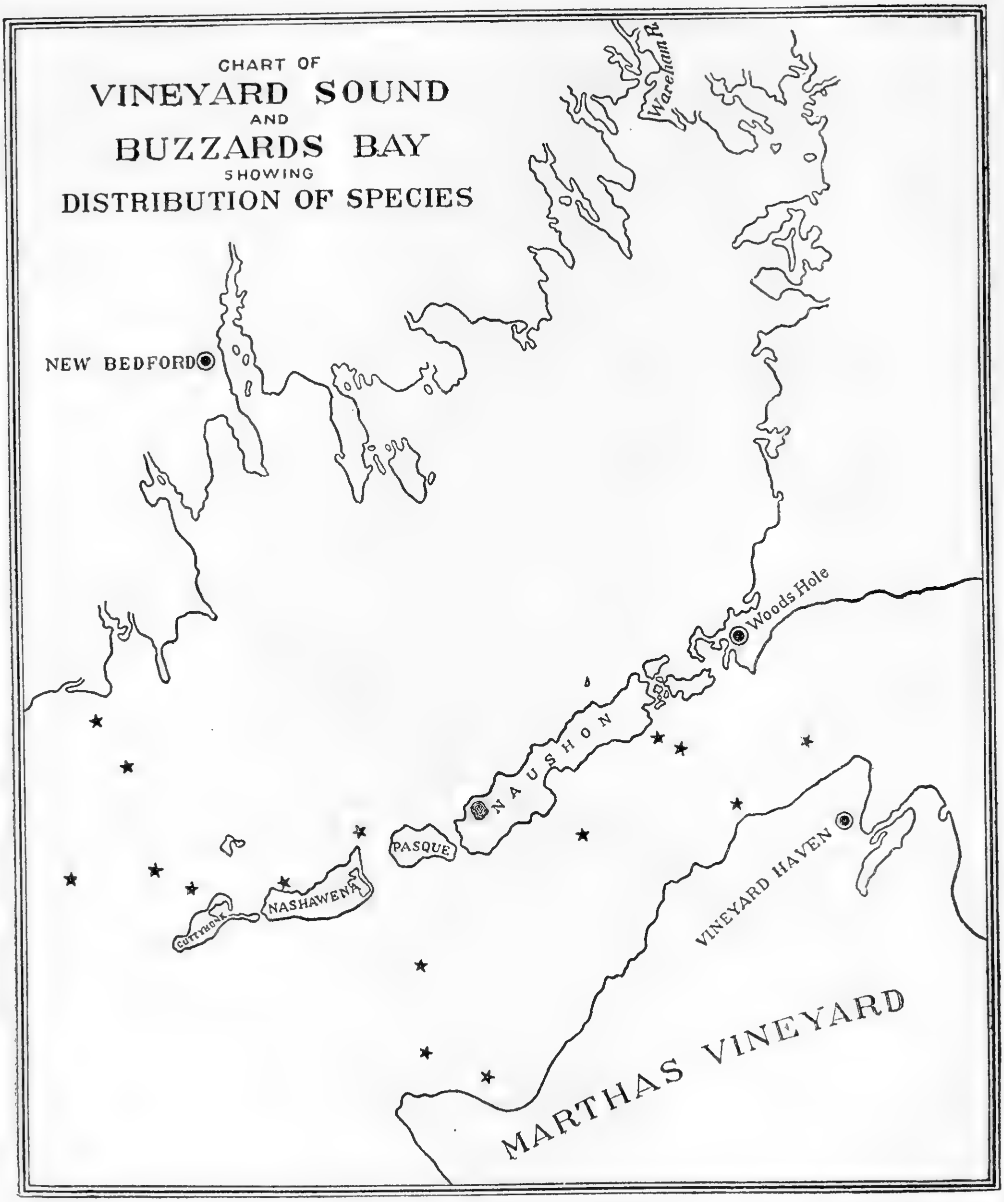

CHART 12.—Chalina sp.

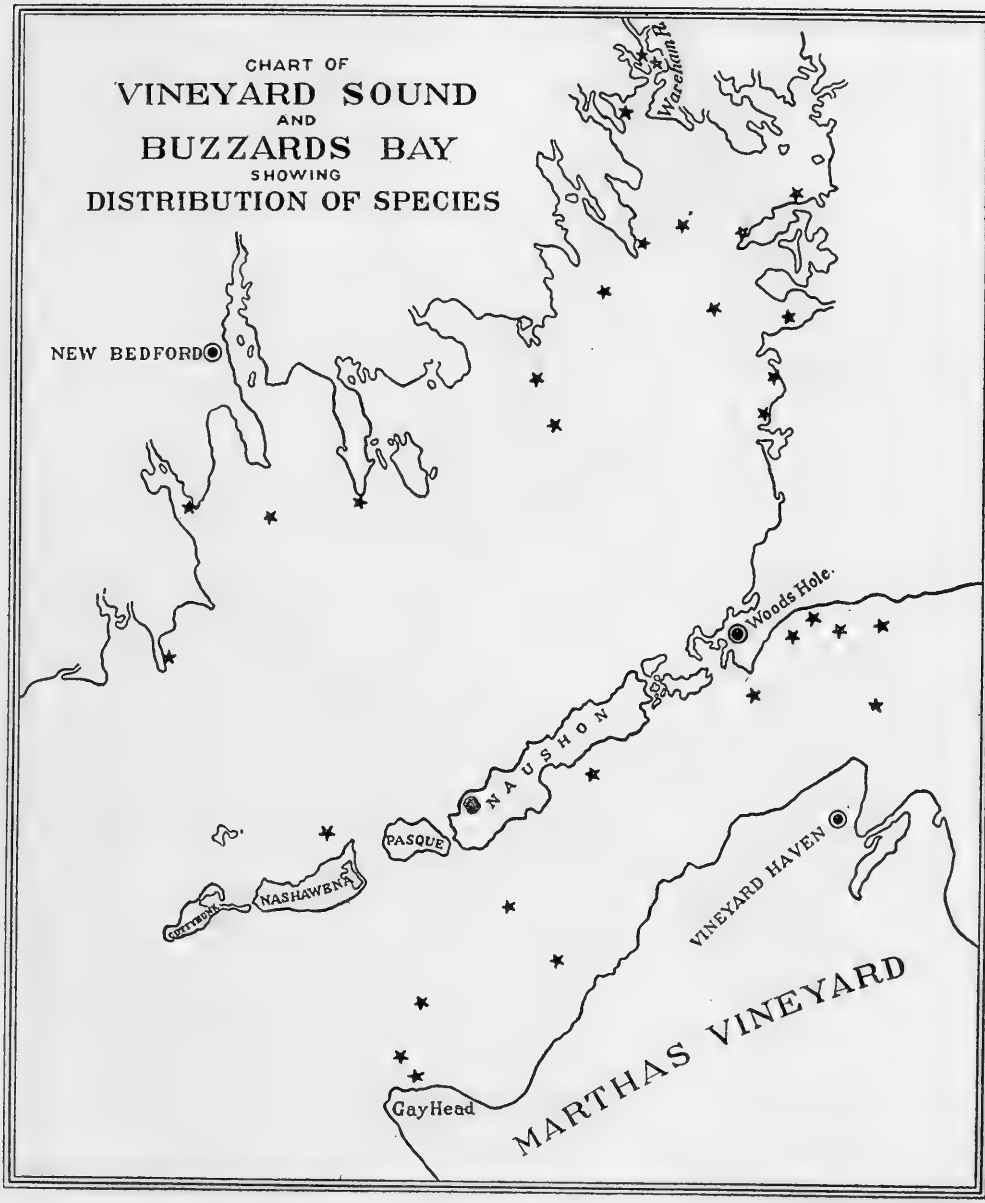

CHART 13.—Microciona prolifera.

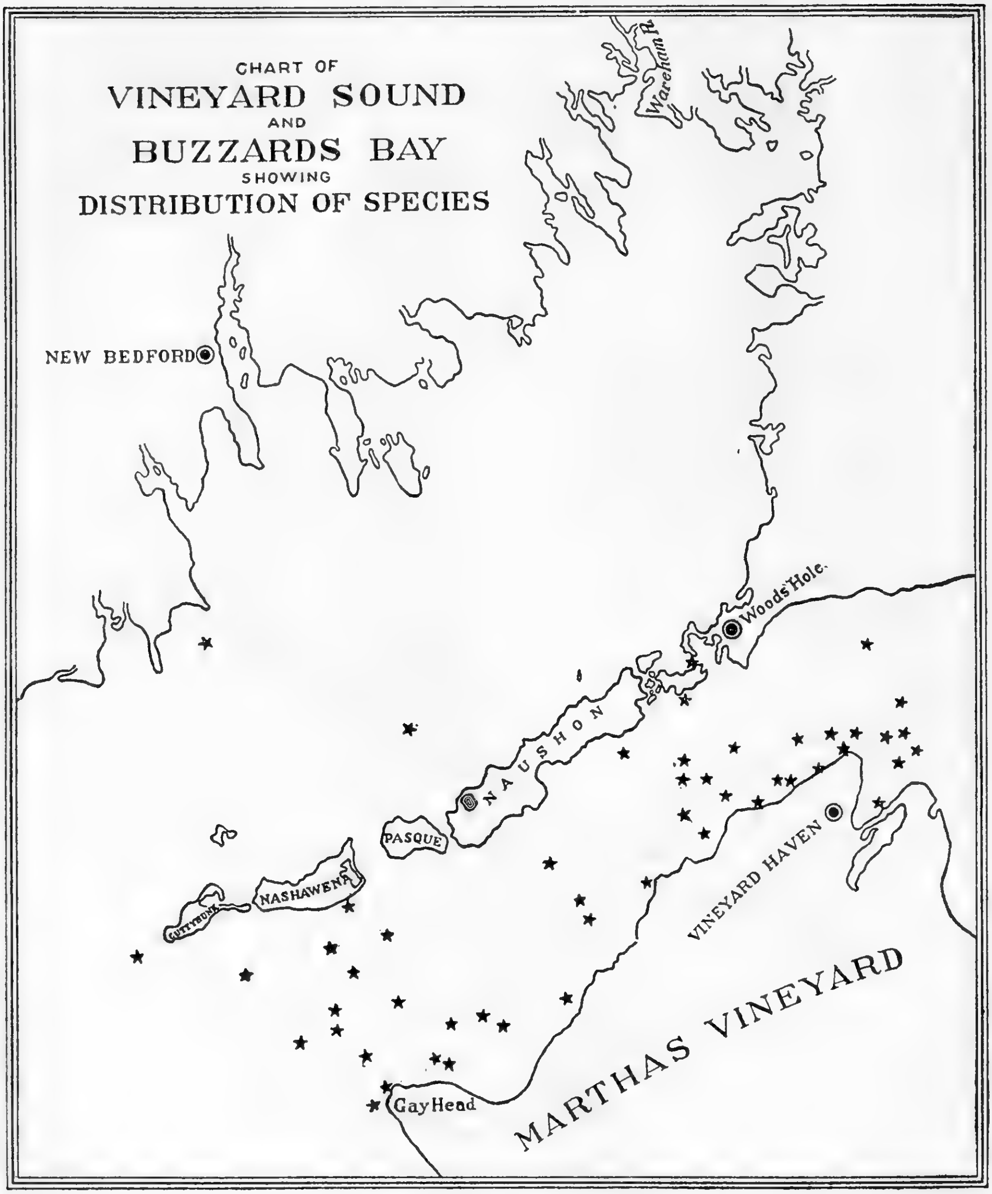

CHART 14.—Pennaria tiarella.

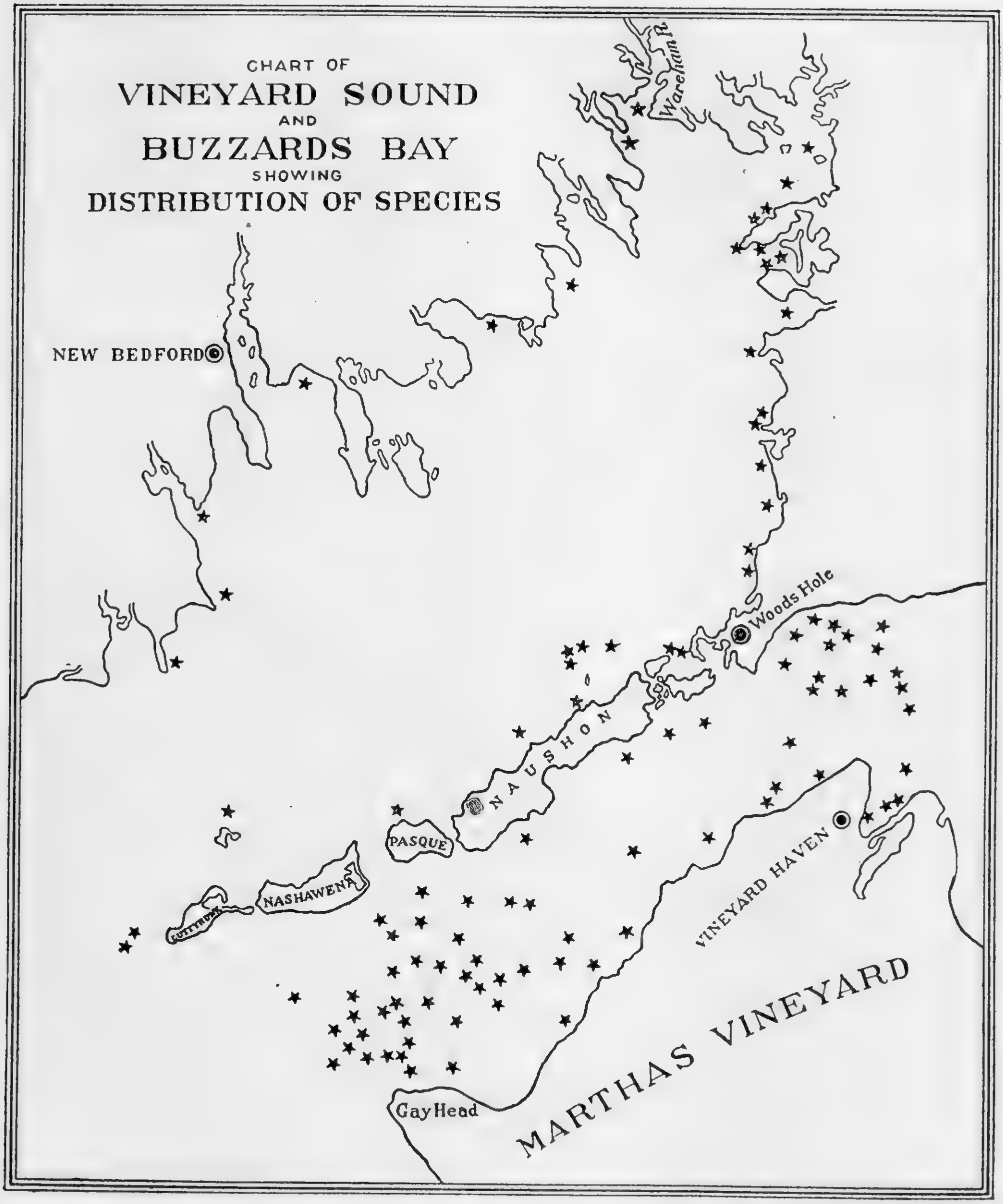

CHART 15.—Hydractinia echinata.

CHART 16.—Eudendrium ramosum.

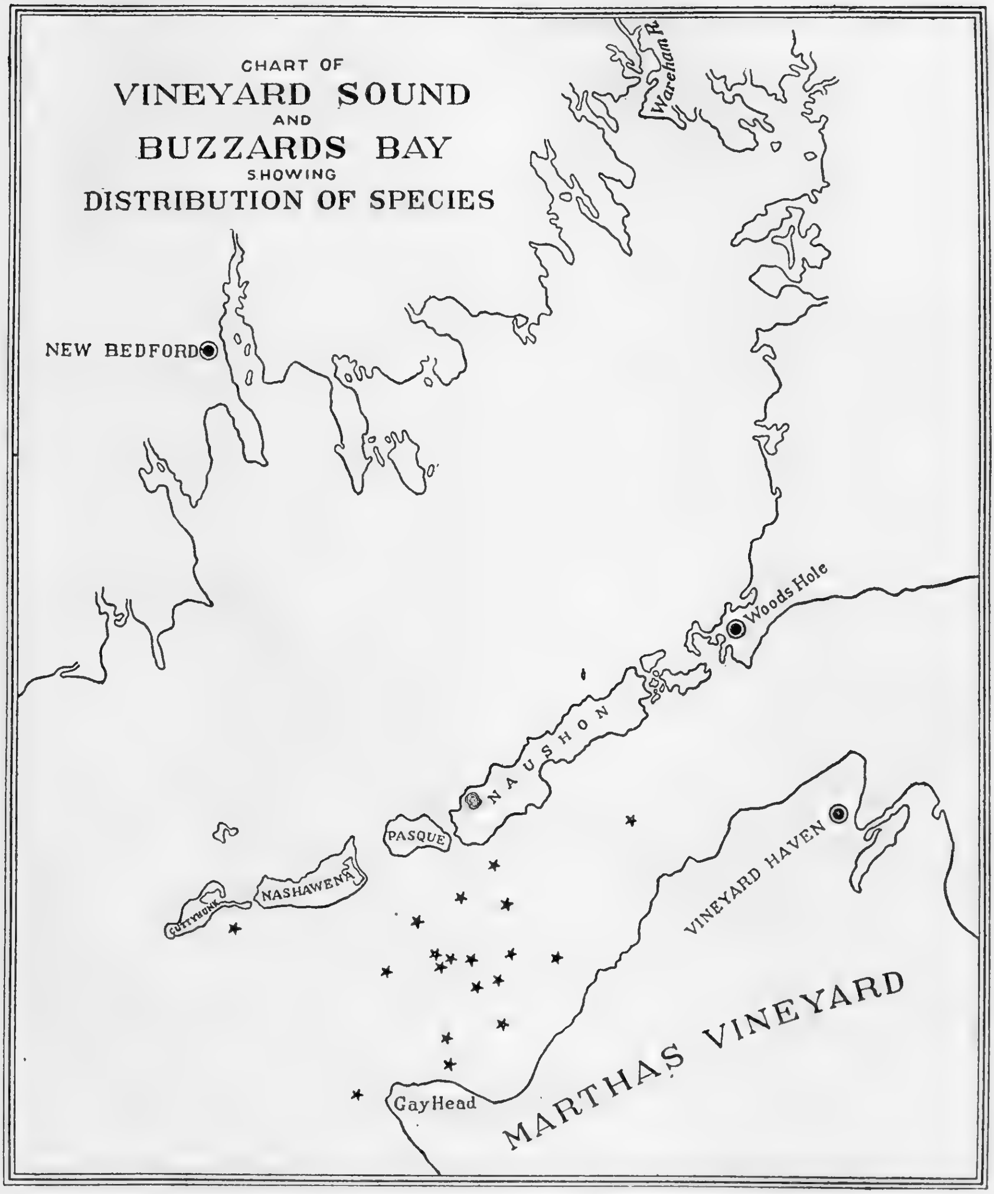

CHART 17.—Eudendrium dispar.

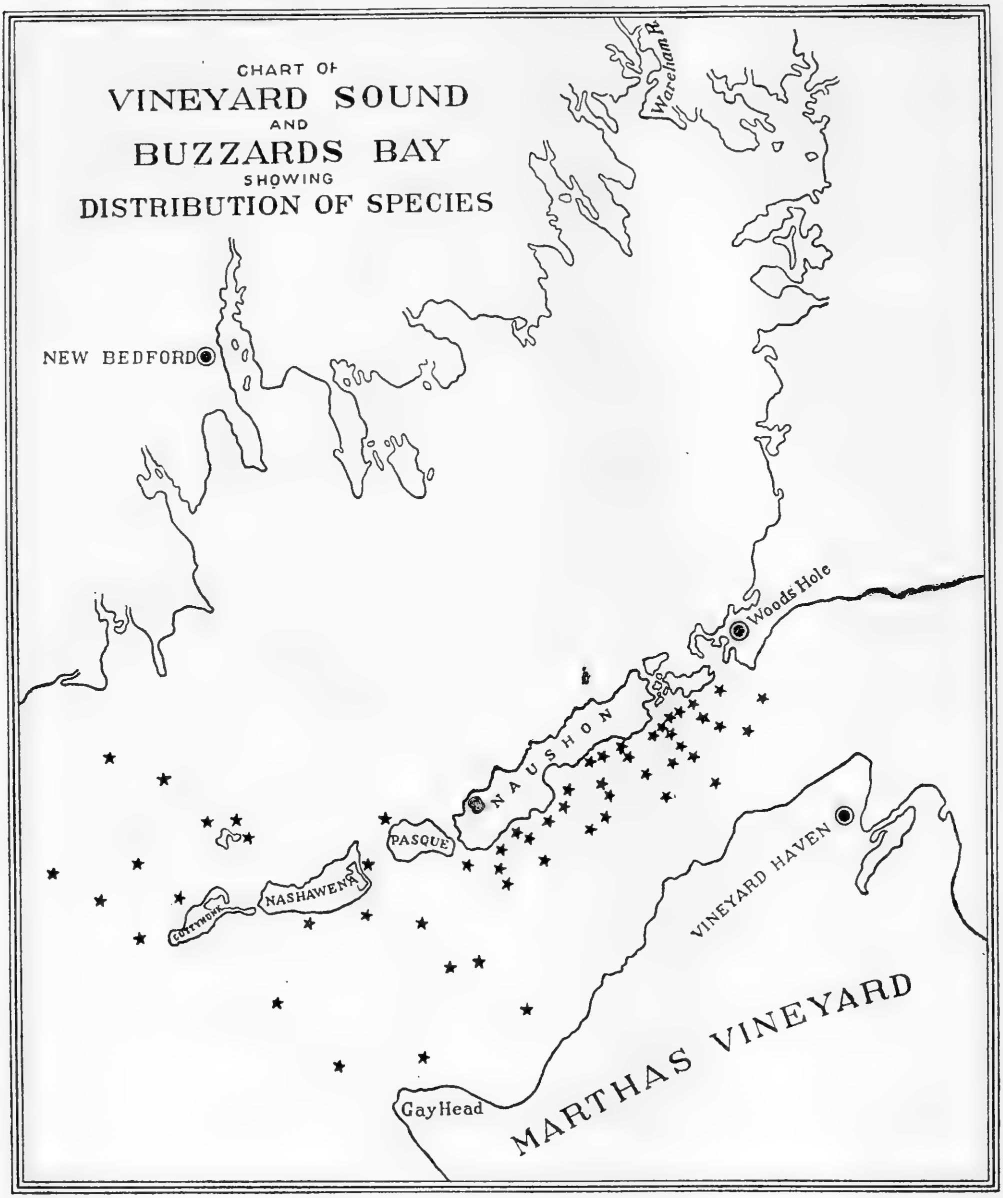

Chart 18.—Tubularia couthouyi.

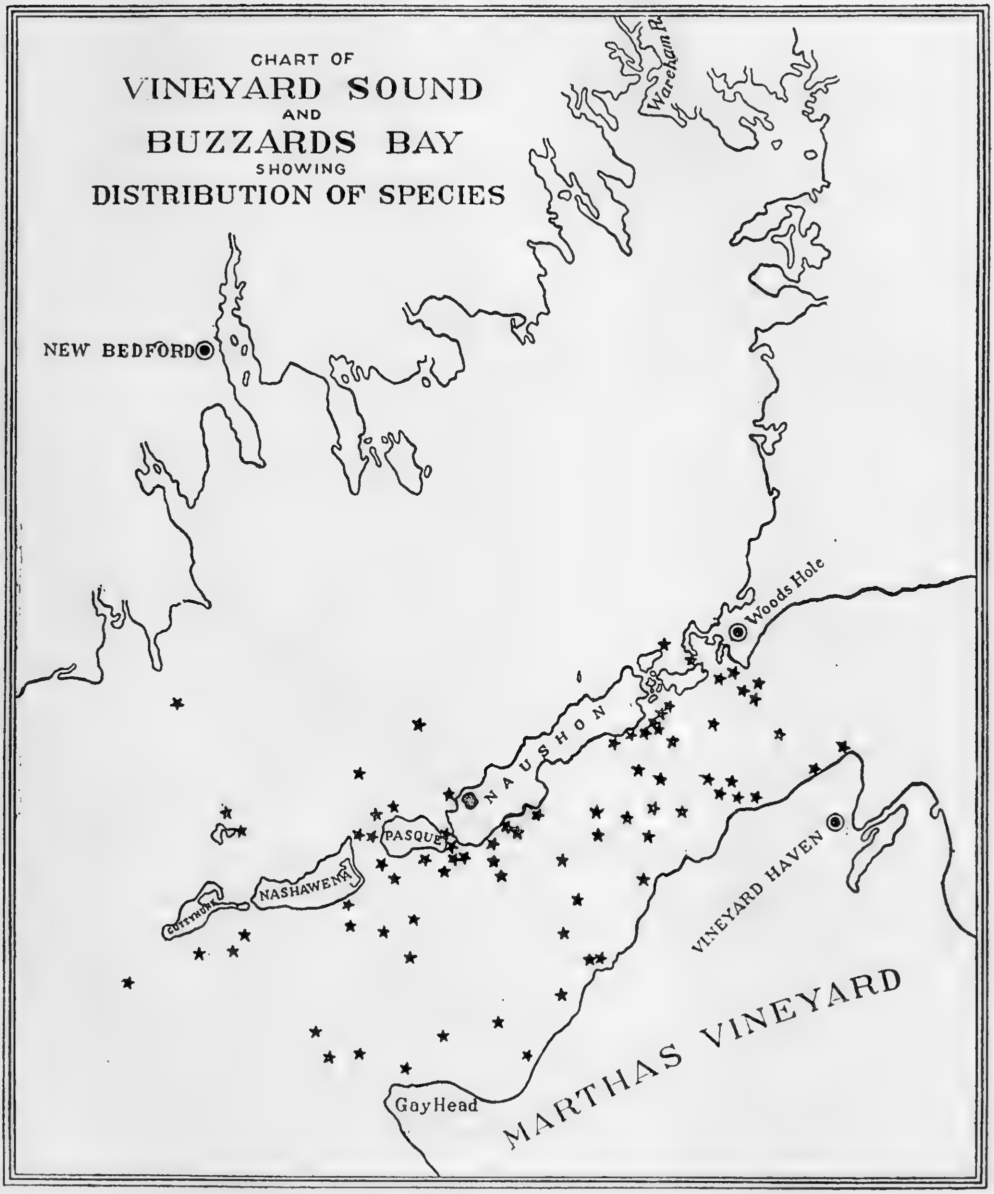

CHART 19.—Tubularia crocea.

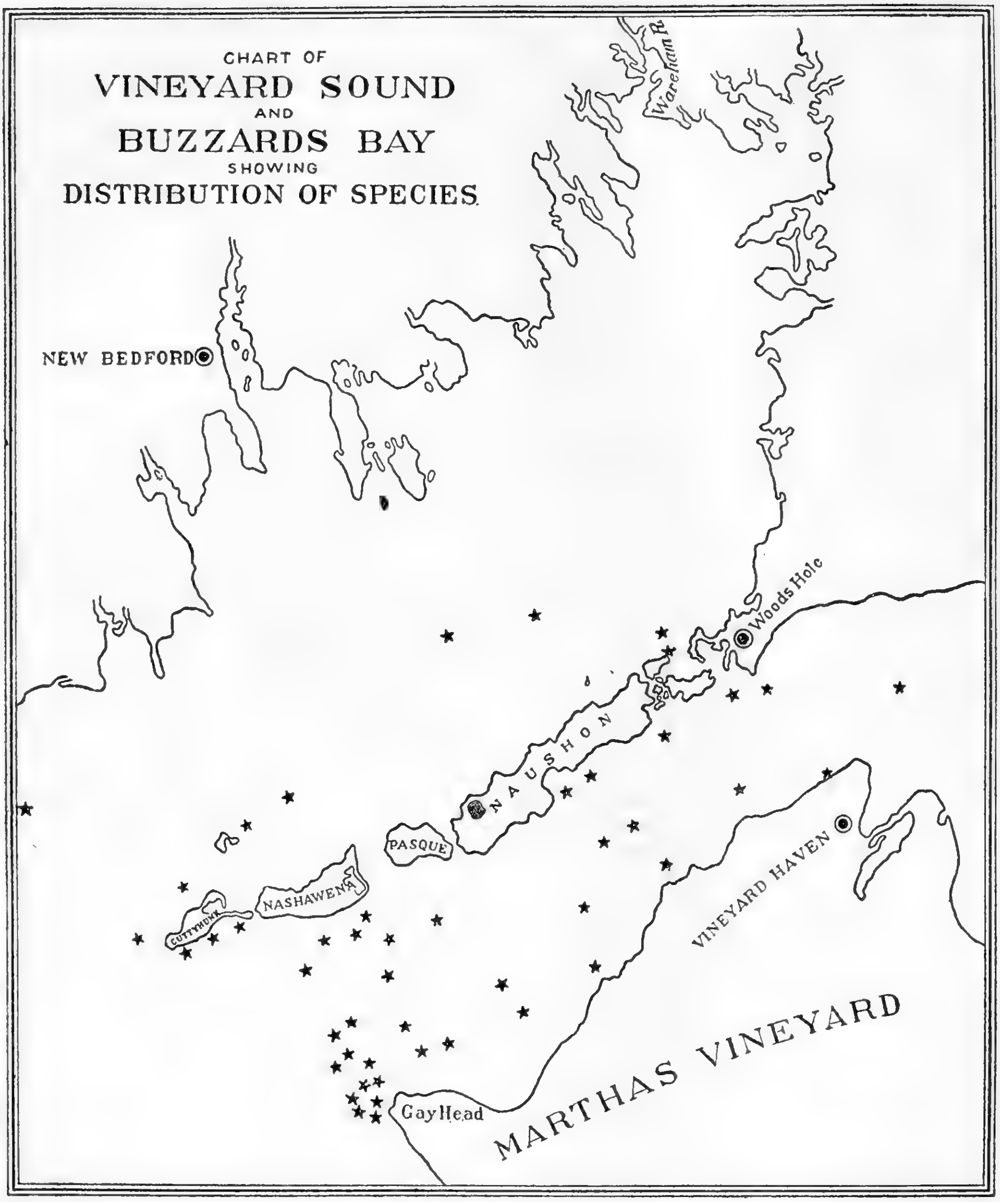

CHART 20.—Obelia geniculata.

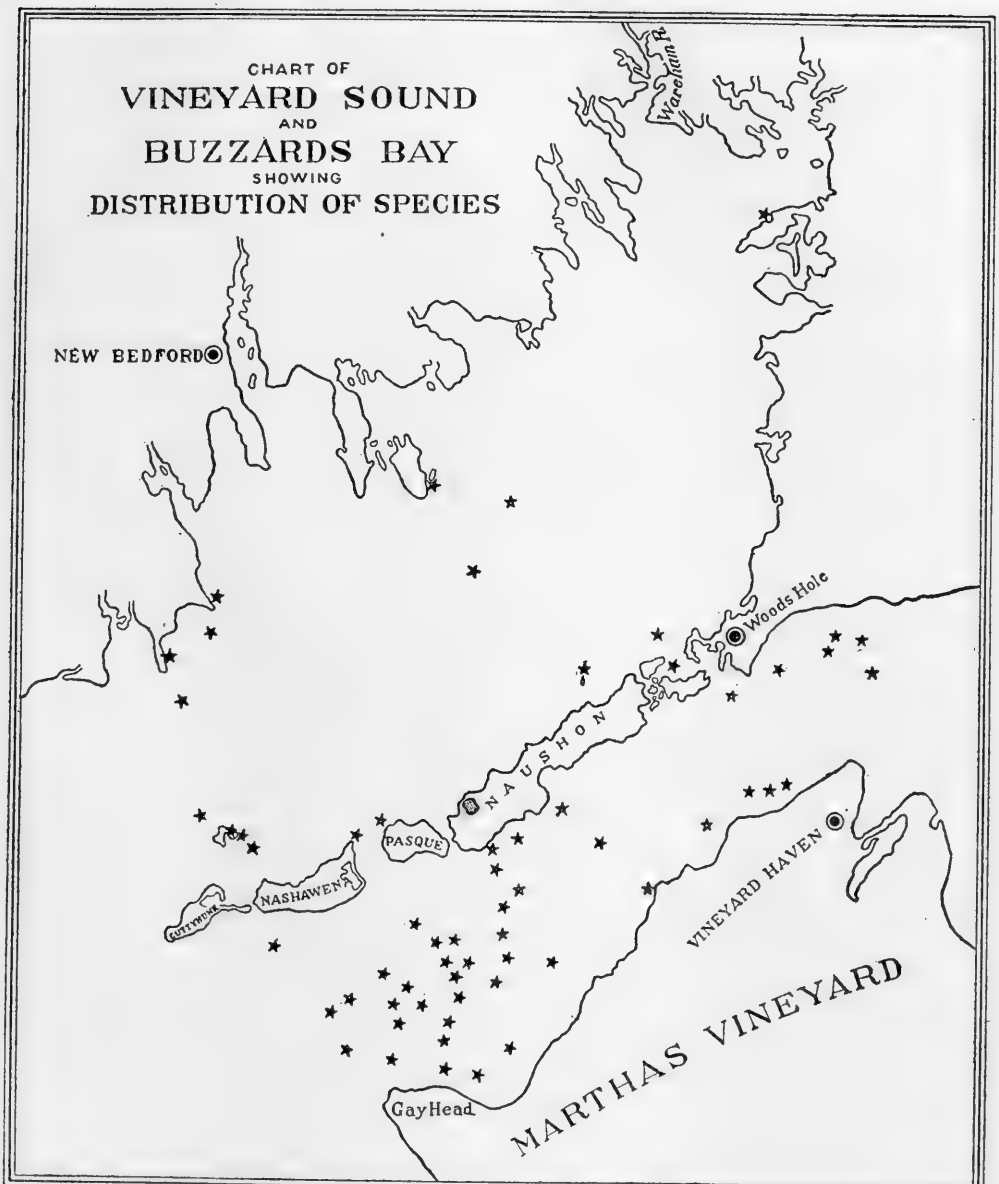

CHART 21.—Halecium halecinum.

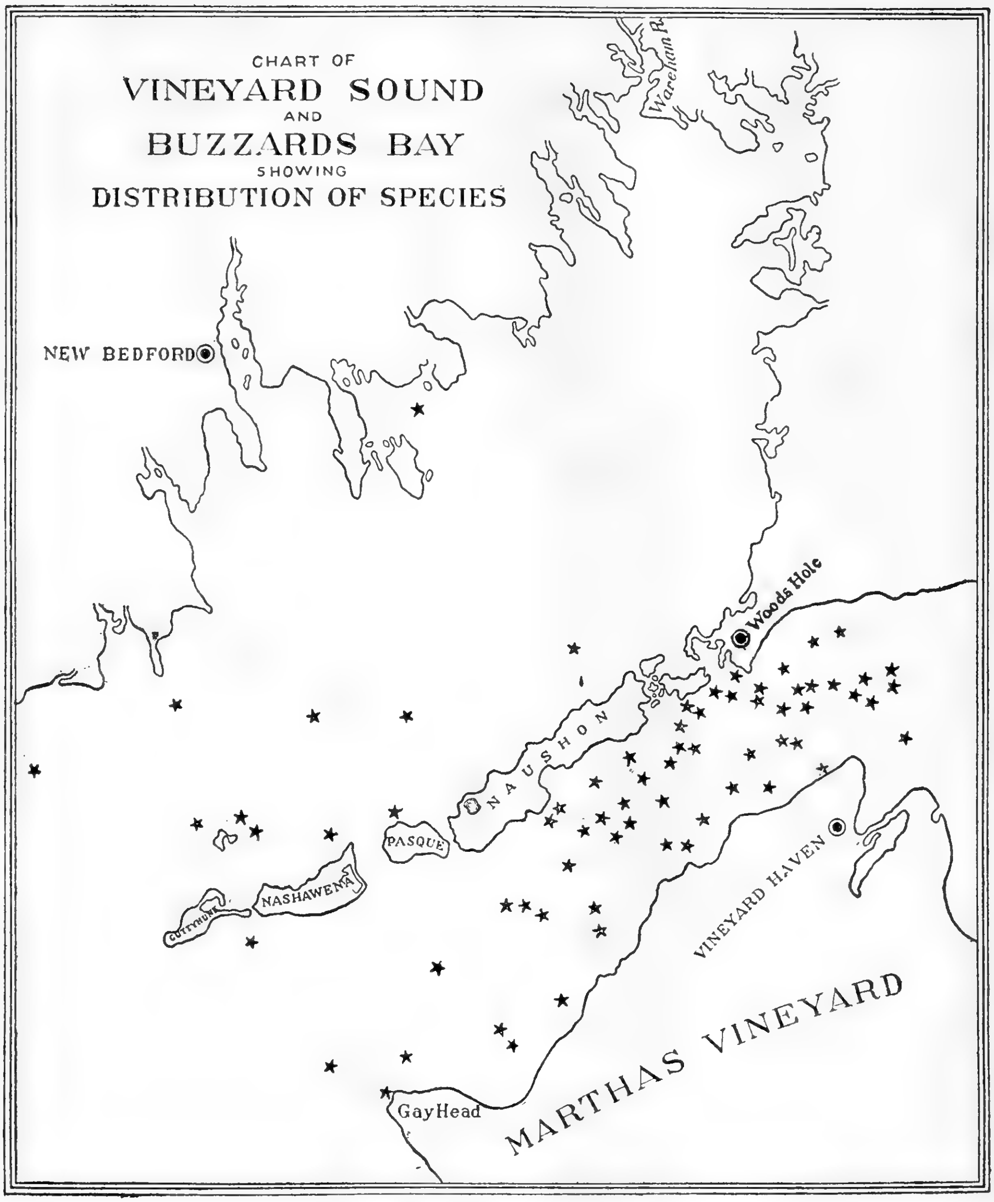

CHART 22.—Thuiaria argentea.

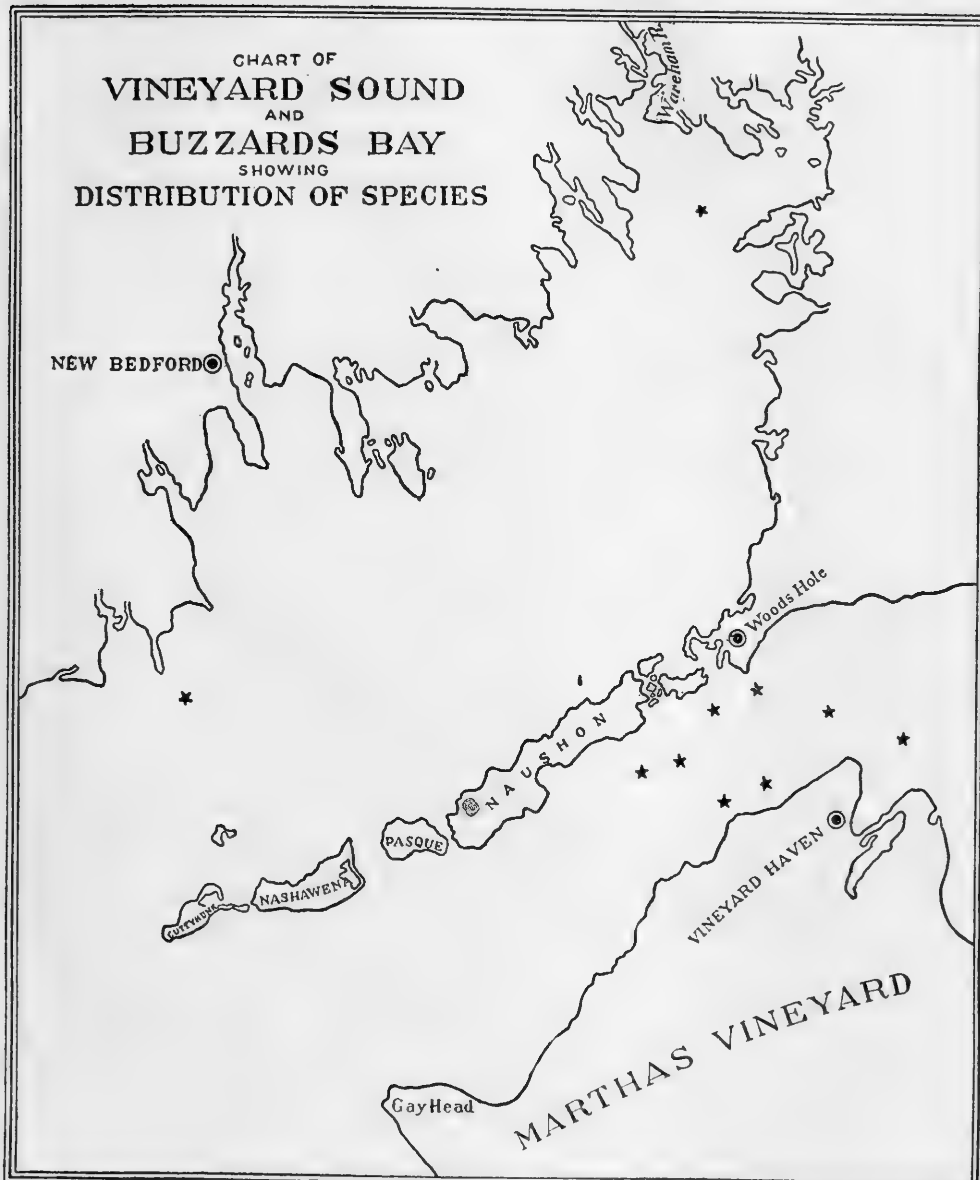

CHART 23.—Schizotricha tenella.

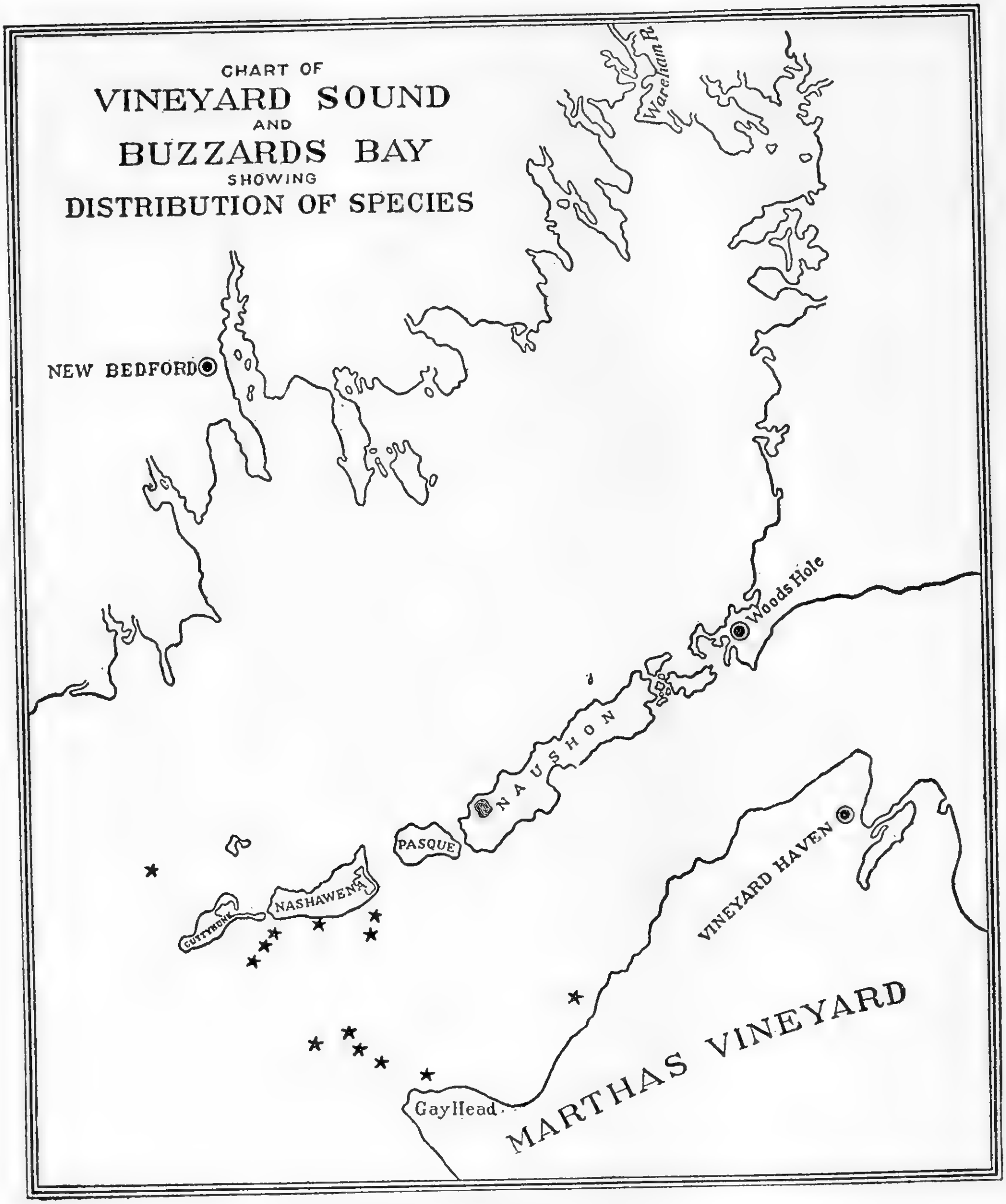

CHART 24.—Alcyonium carneum.

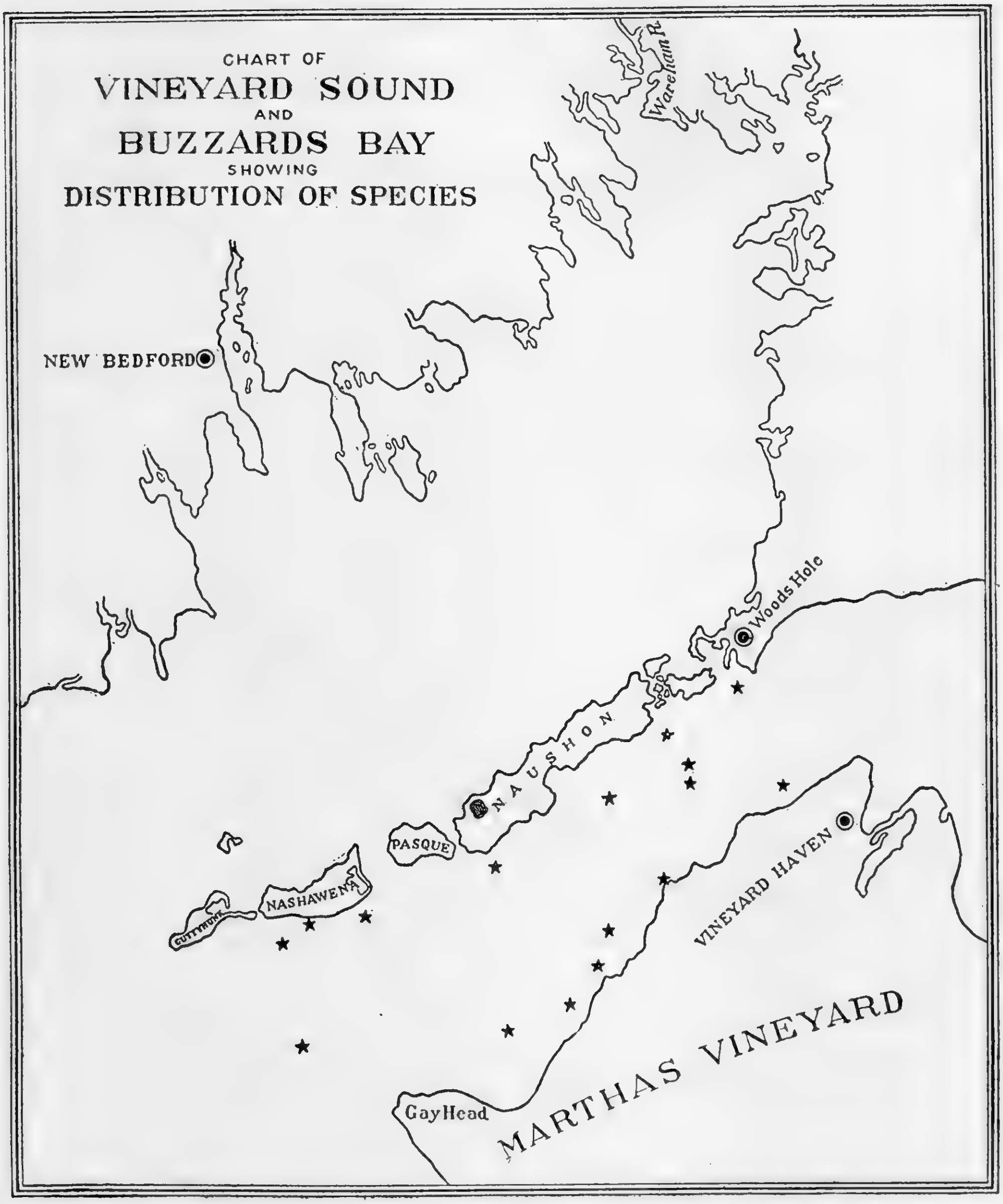

CHART 25.—Metridium dianthus.

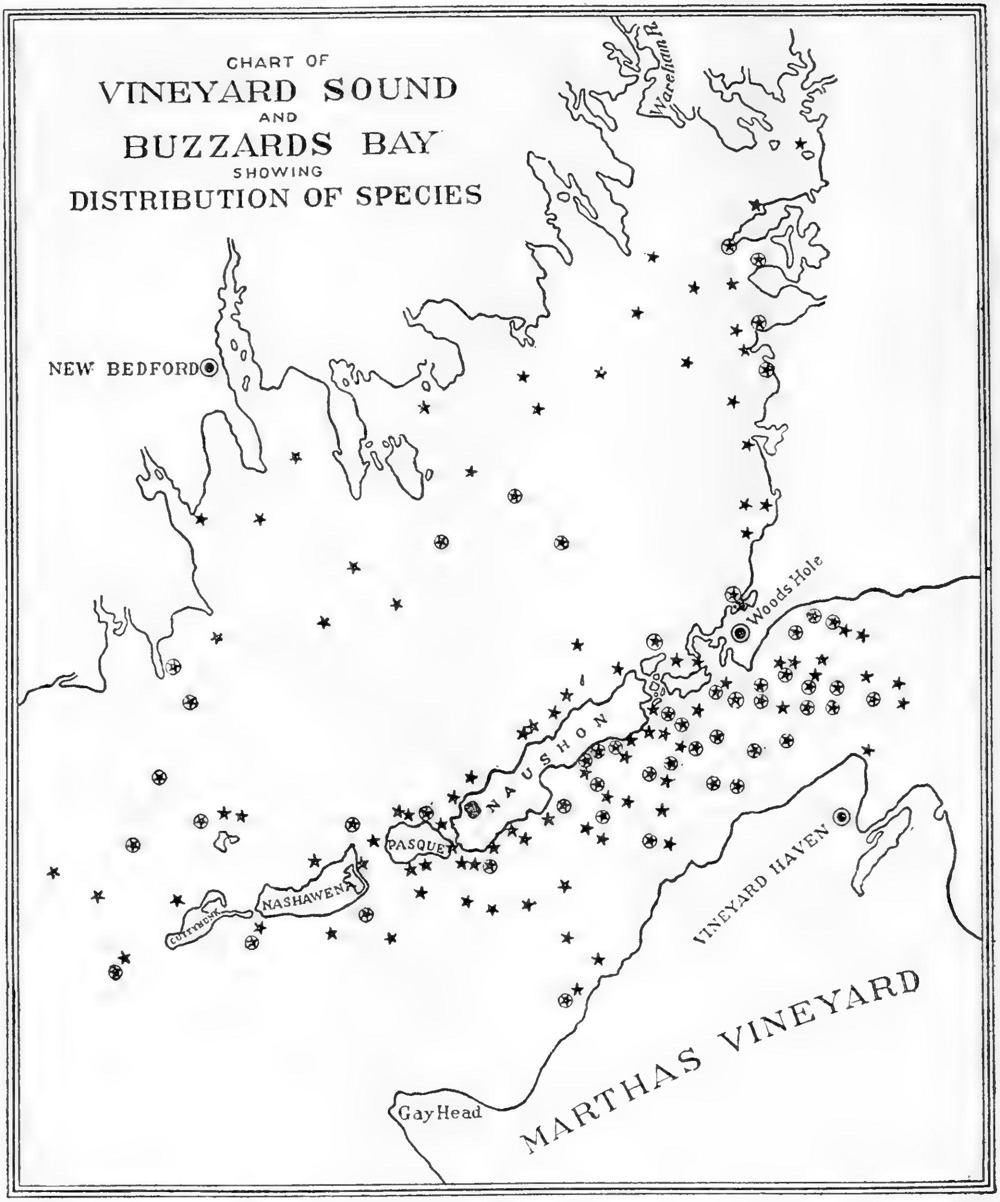

CHART 26.—Astrangia danæ.

Upon the chart for this coral, and those for the shell-bearing echinoderms and mollusks, the circles surrounding certain stars denote that living specimens were recorded from the stations thus designated. The absence of a circle at a given station denotes either that dead remains alone were recorded or that the records do not indicate the condition of the specimens. This practice has not been followed except in the case of shell-bearing organisms. For others, it may be assumed that the records nearly always relate to living specimens.

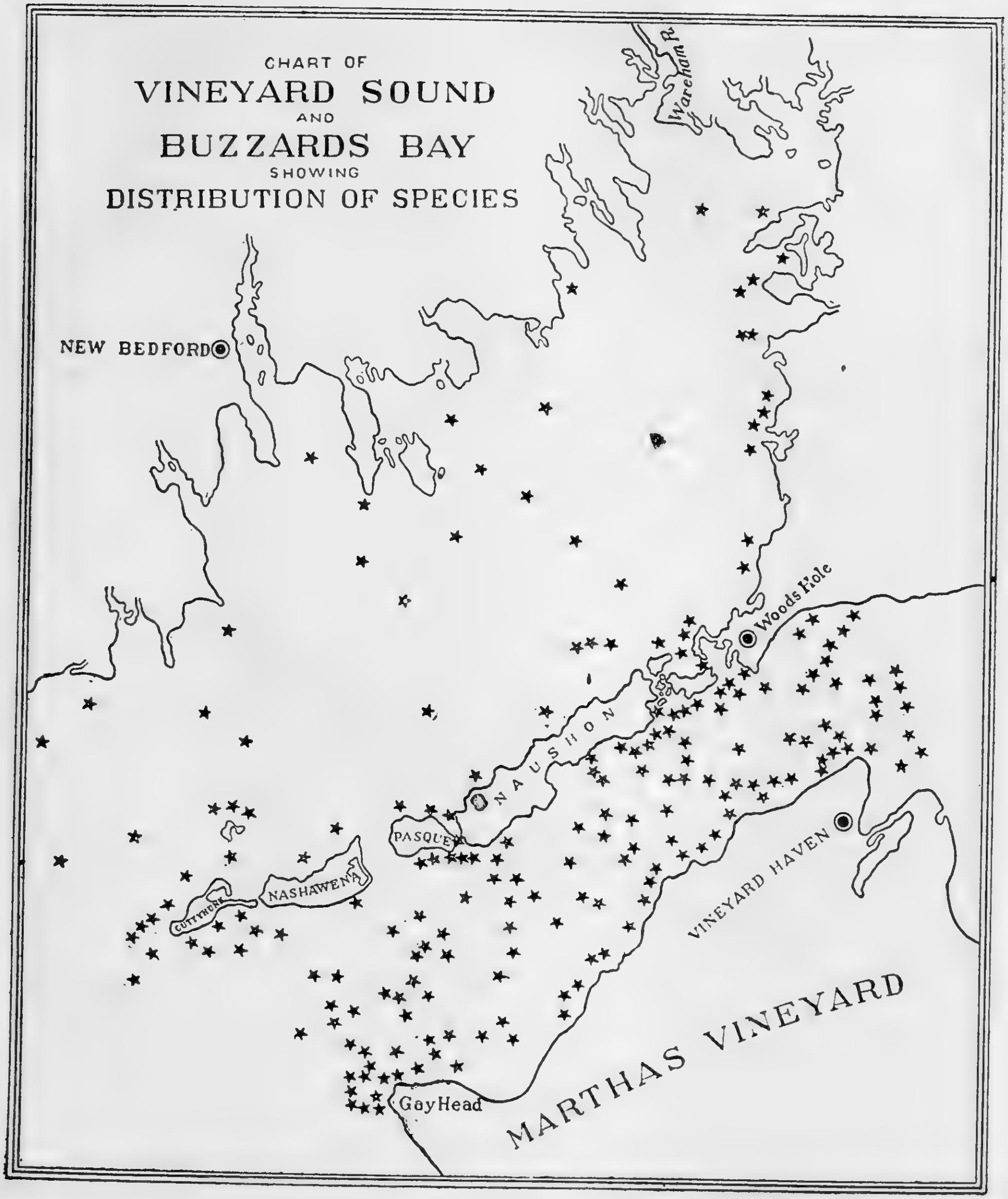

CHART 27.—Crisia eburnea.

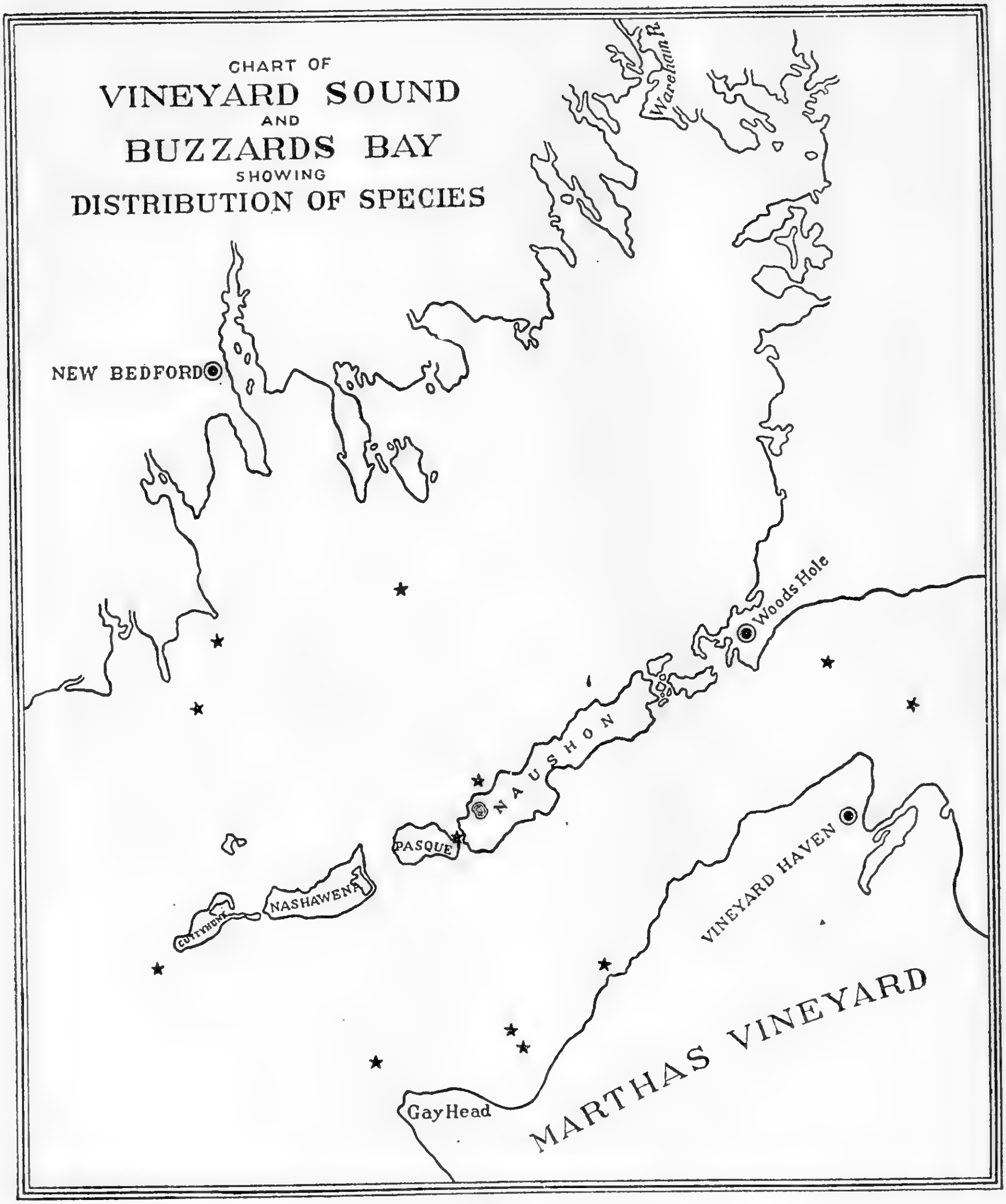

CHART 28.—Tubulipora liliacea.

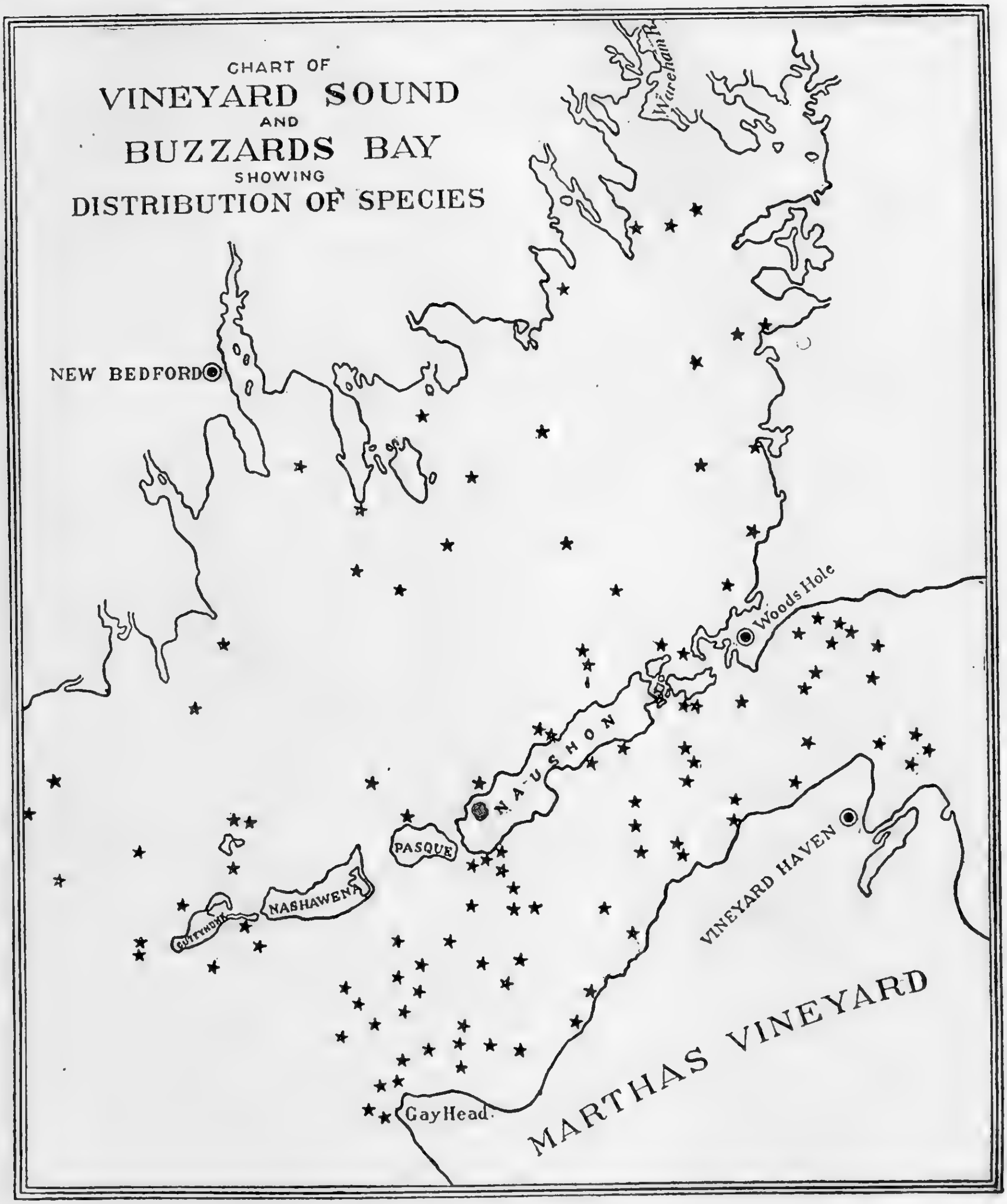

CHART 29.—Ætea anguina.

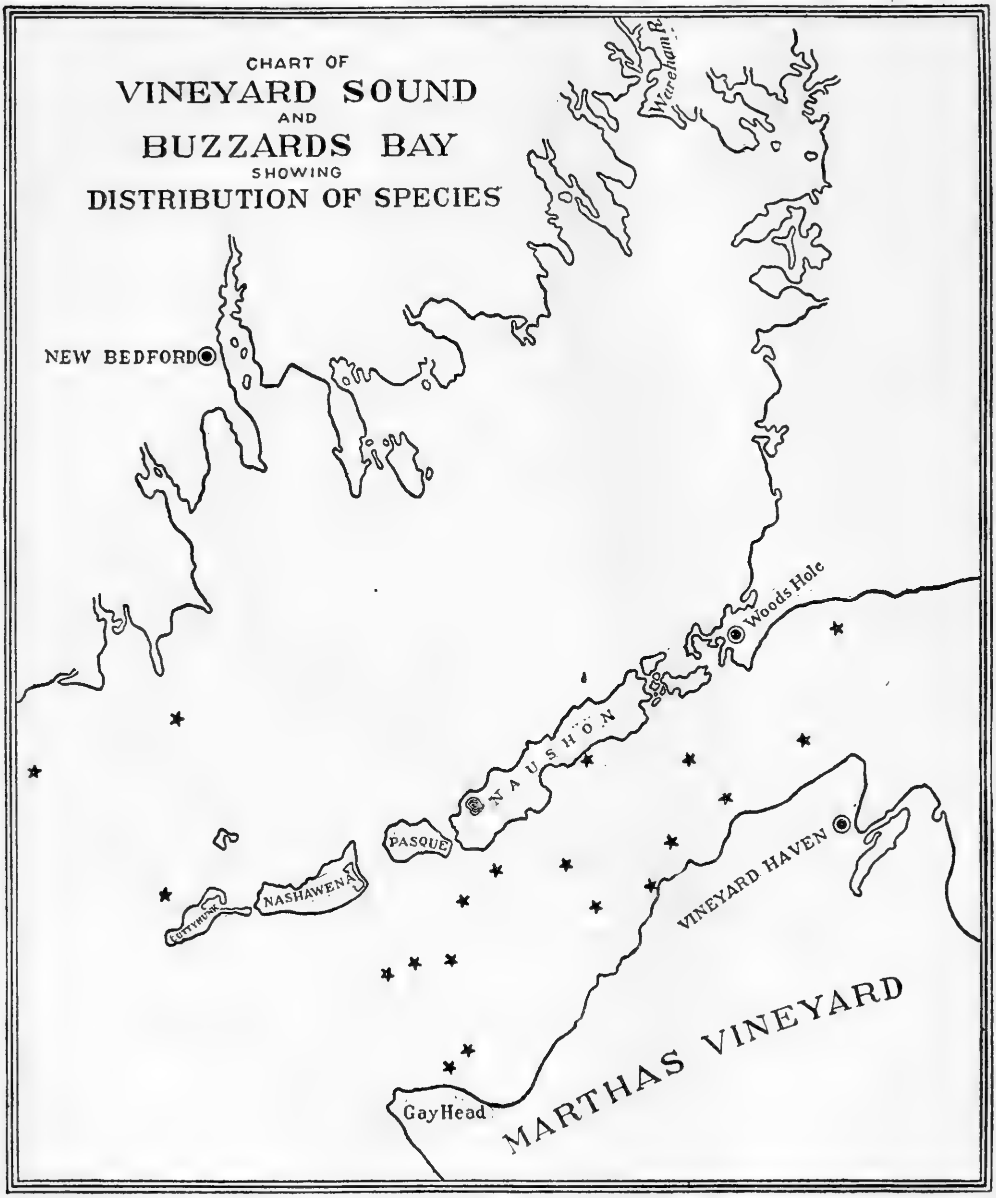

CHART 30.—Bicellaria ciliata.

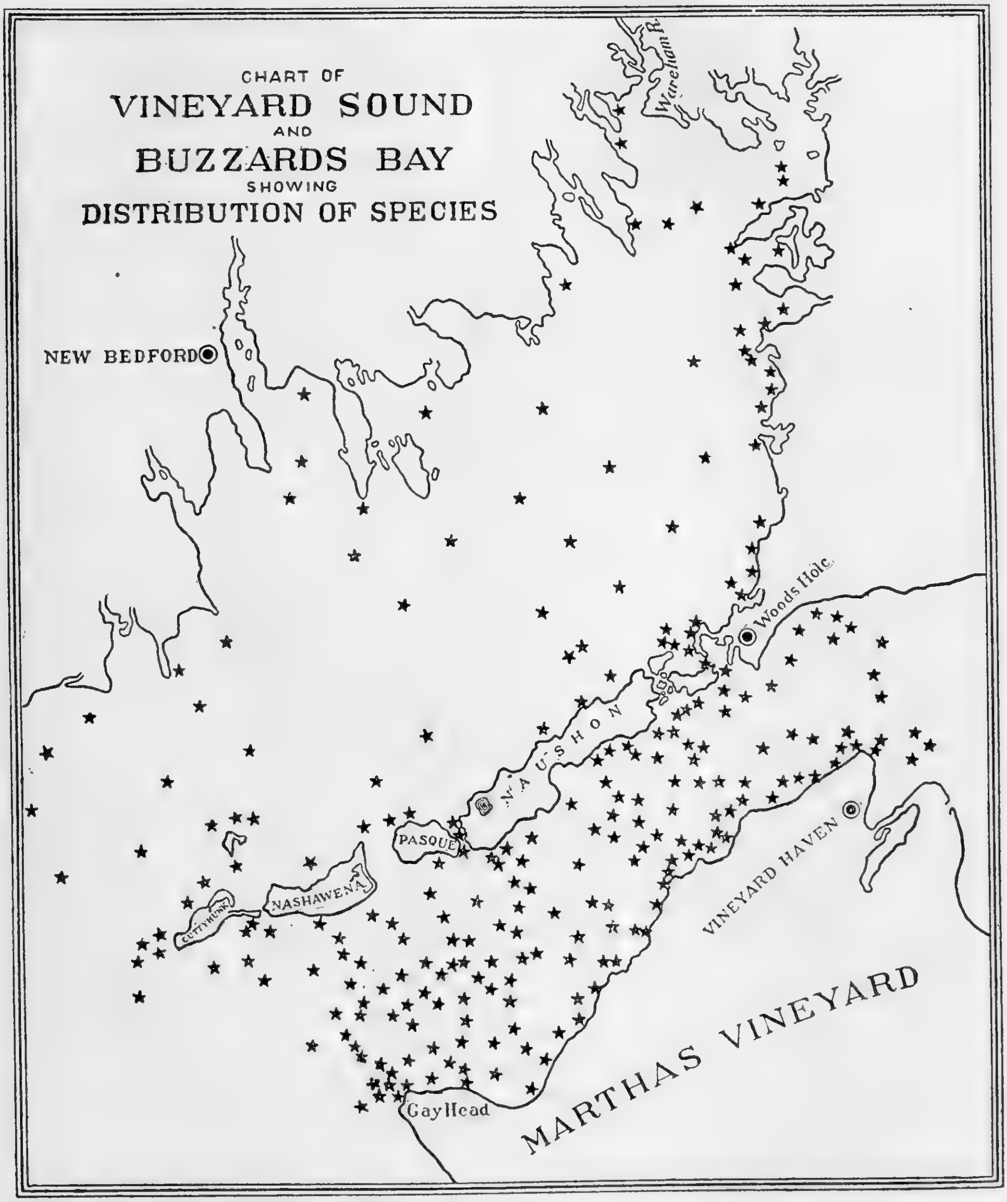

CHART 31.—Bugula turrita.

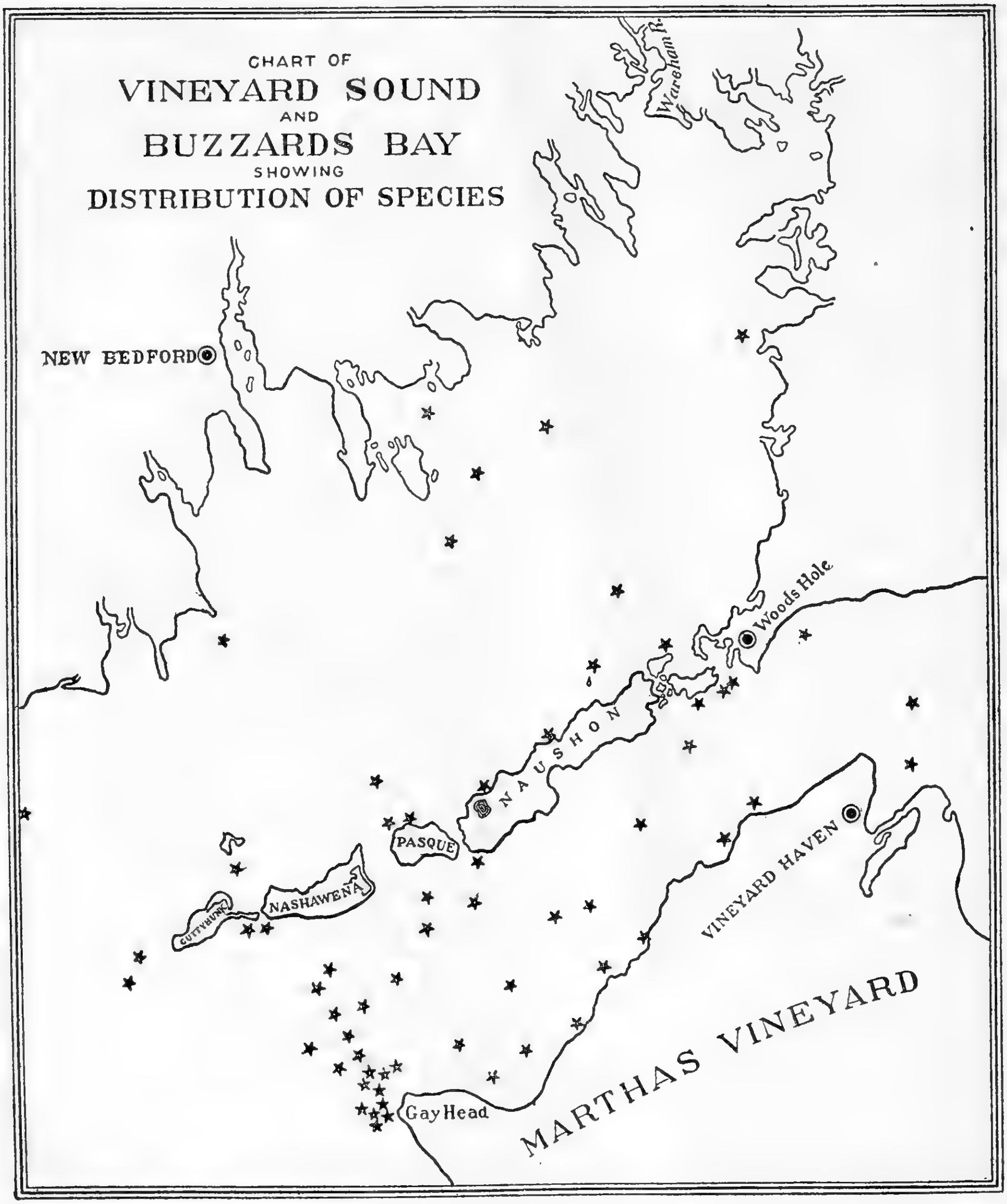

CHART 32.—Membranipora pilosa.

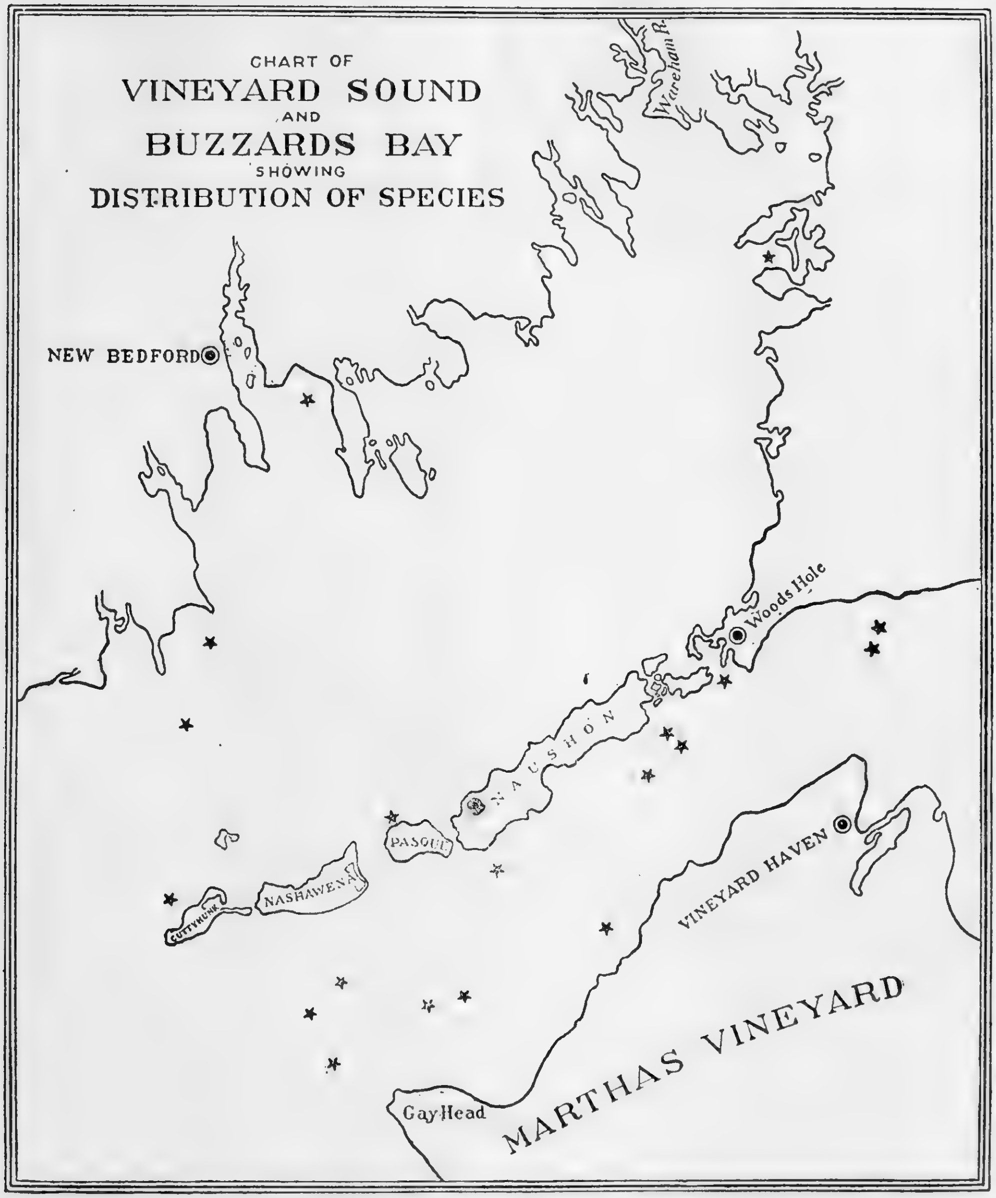

CHART 33.—Membranipora monostachys.

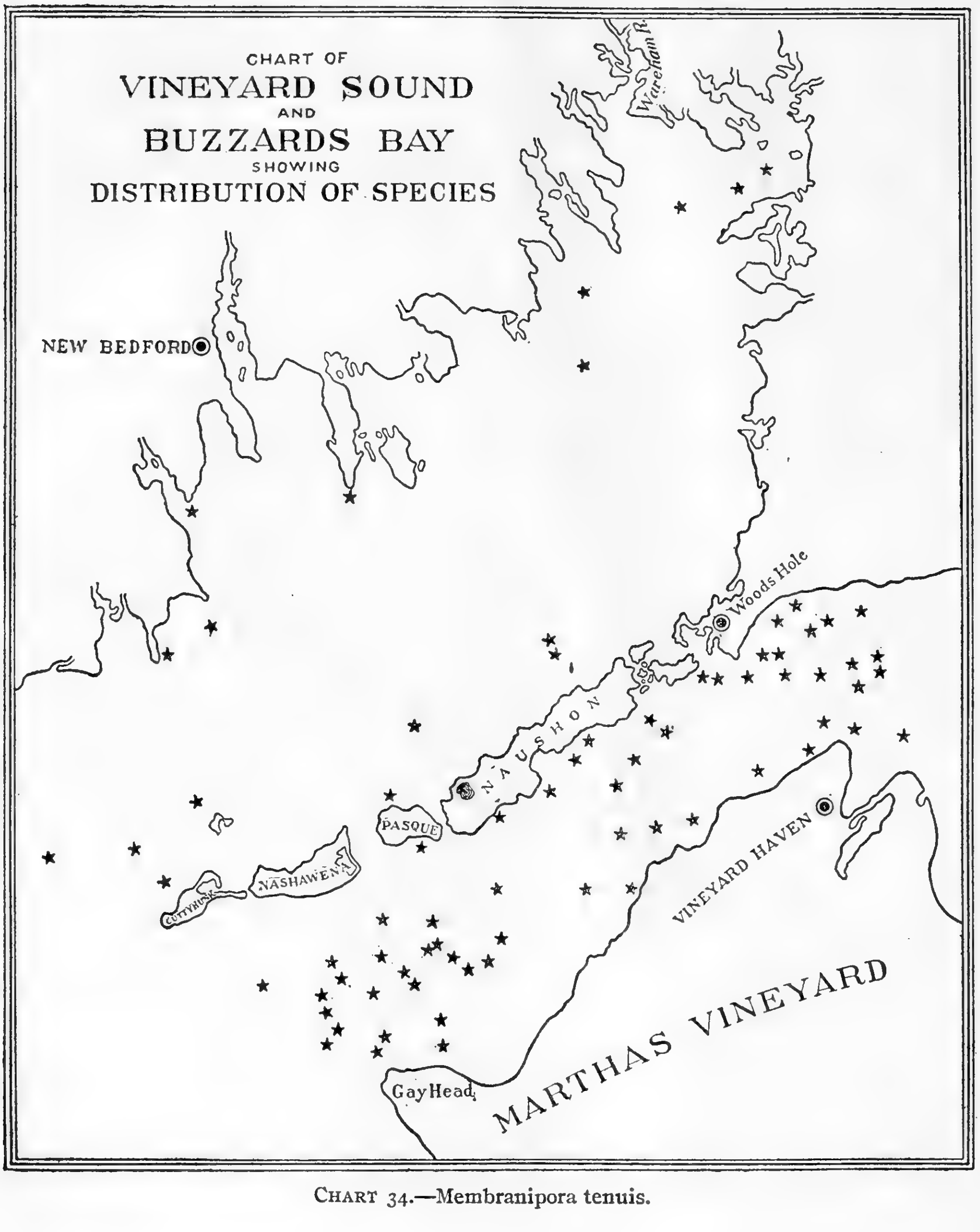

CHART 34.—Membranipora tenuis.

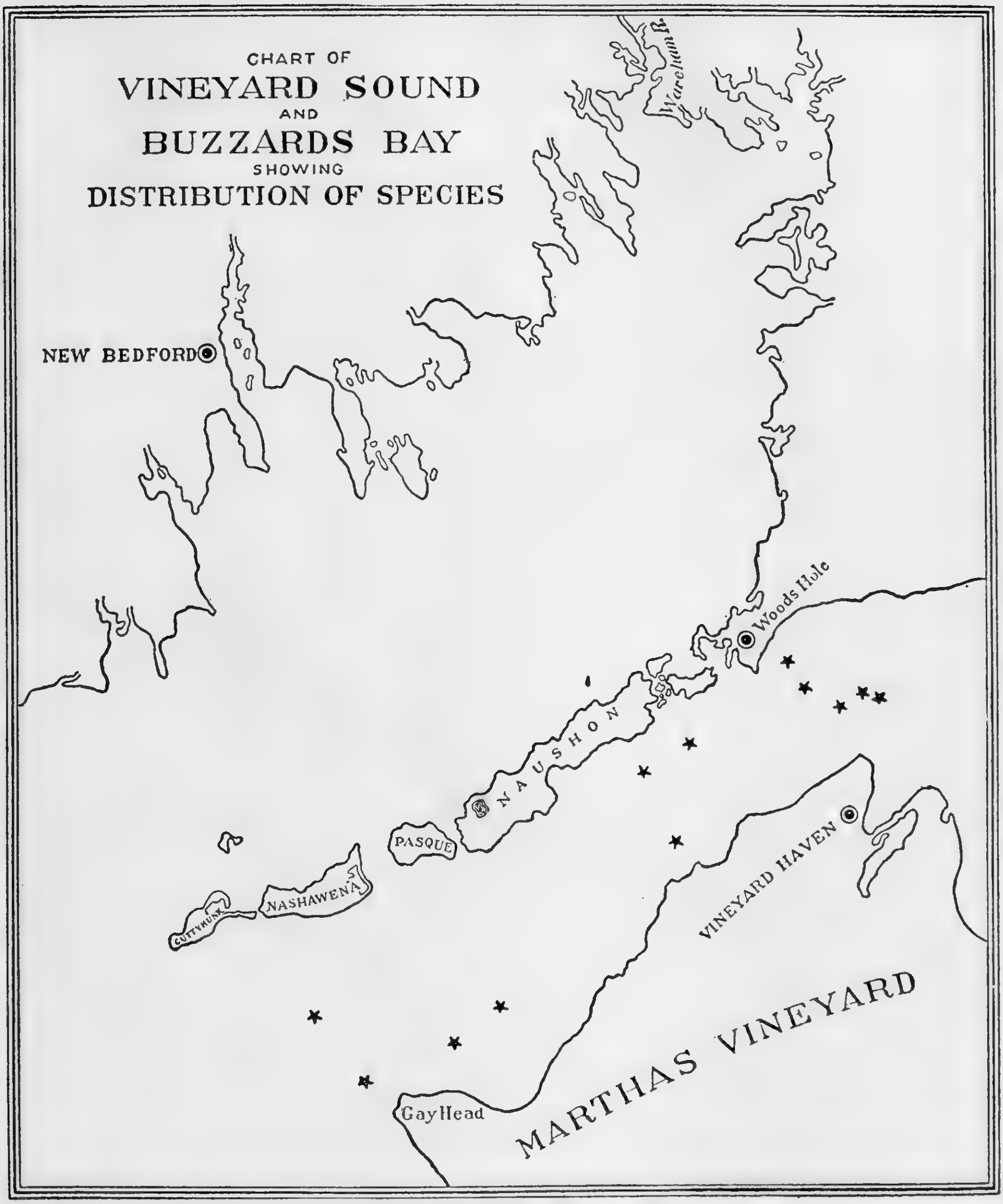

CHART 35.—Membranipora flemingii.

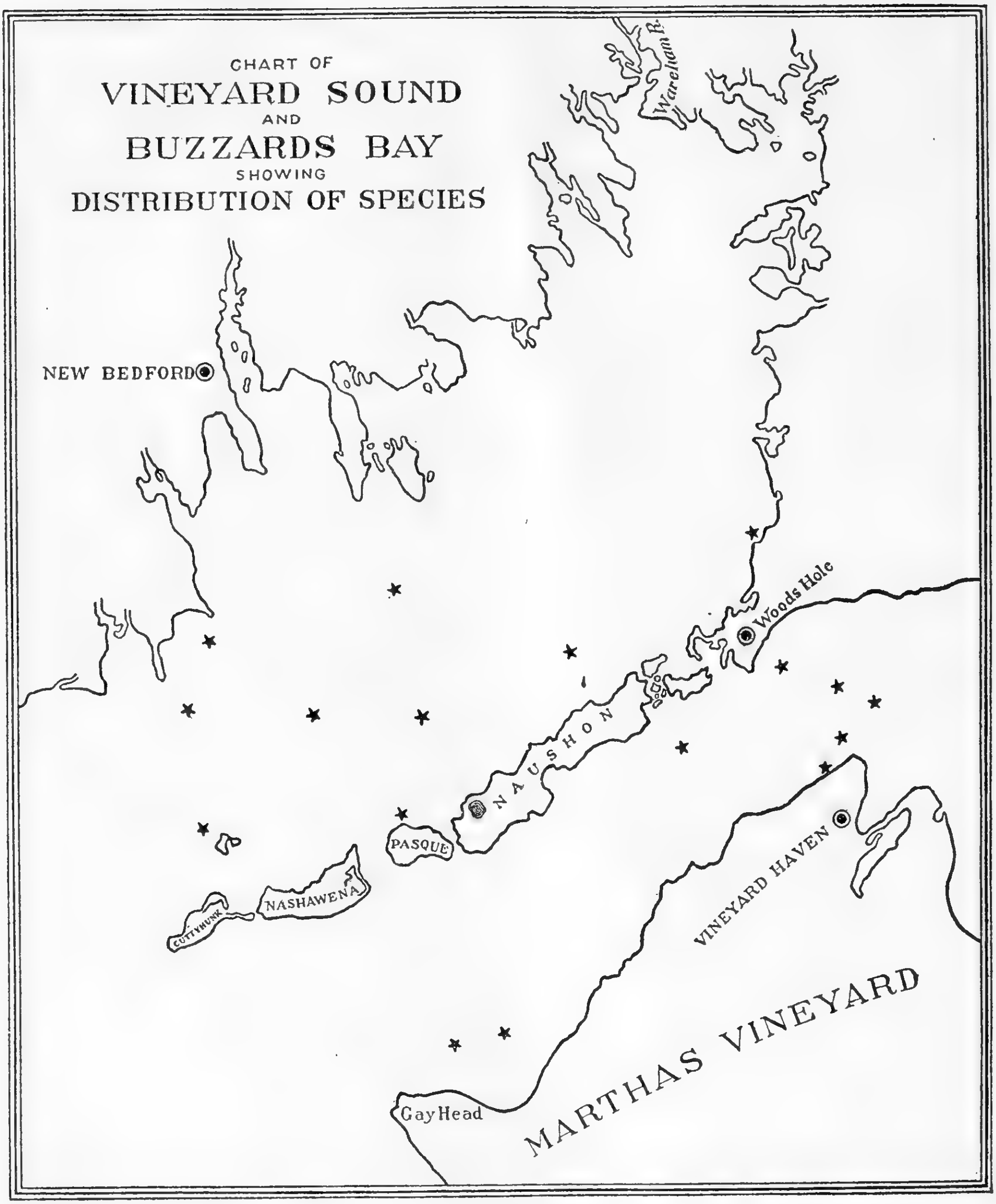

CHART 36.—Membranipora aurita.

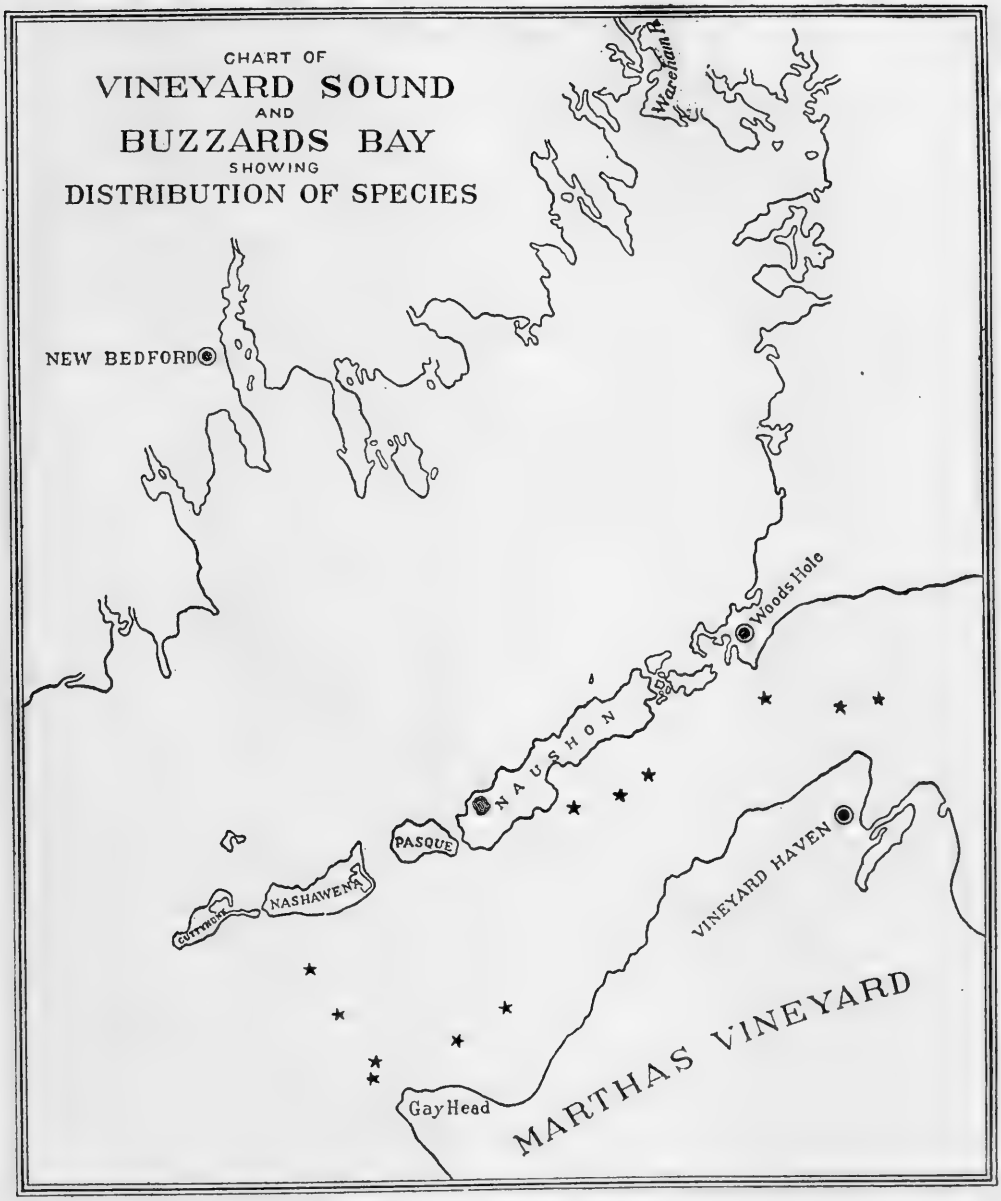

CHART 37.—Cribrilina punctata.

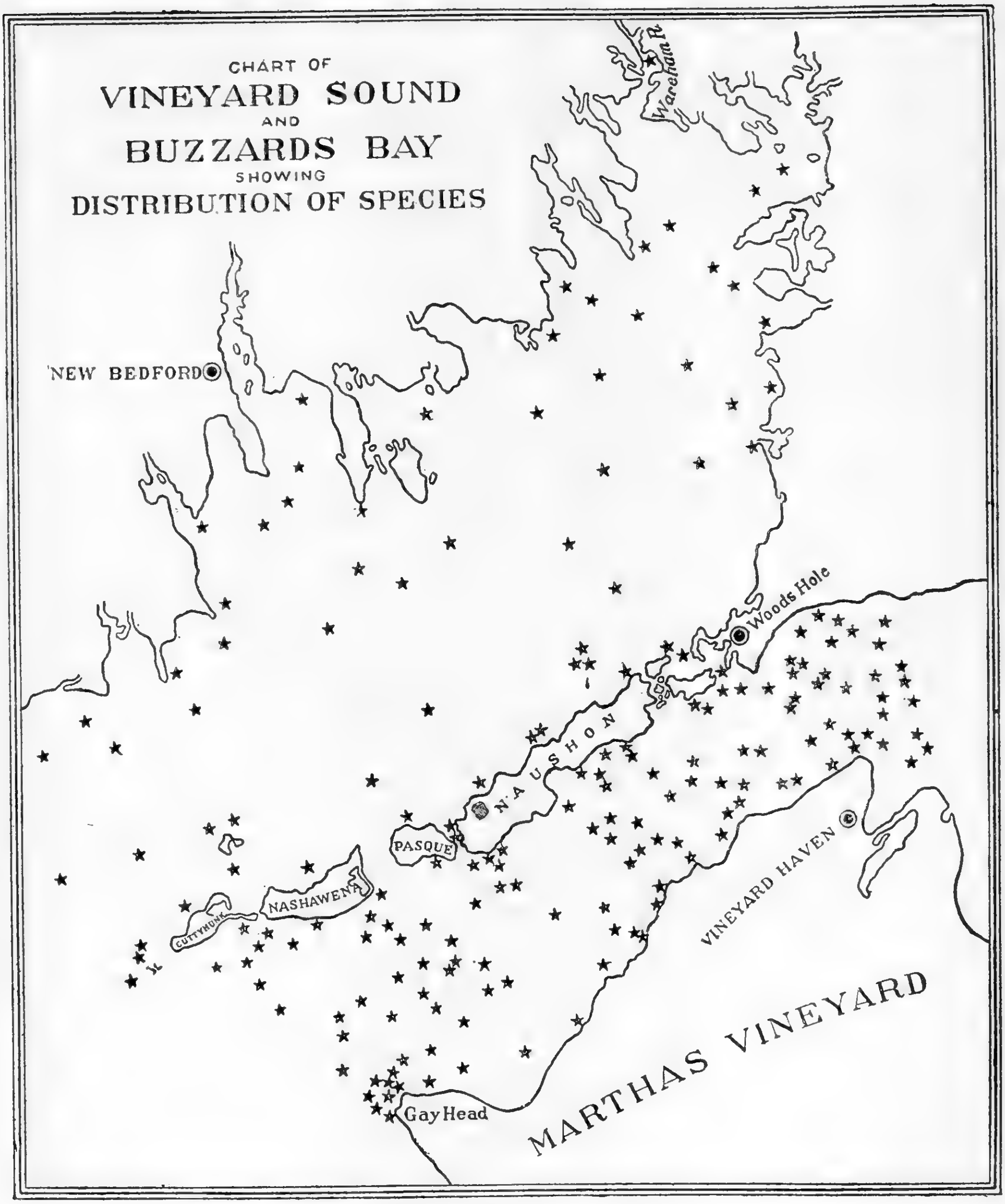

CHART 38.—Schizoporella unicornis.

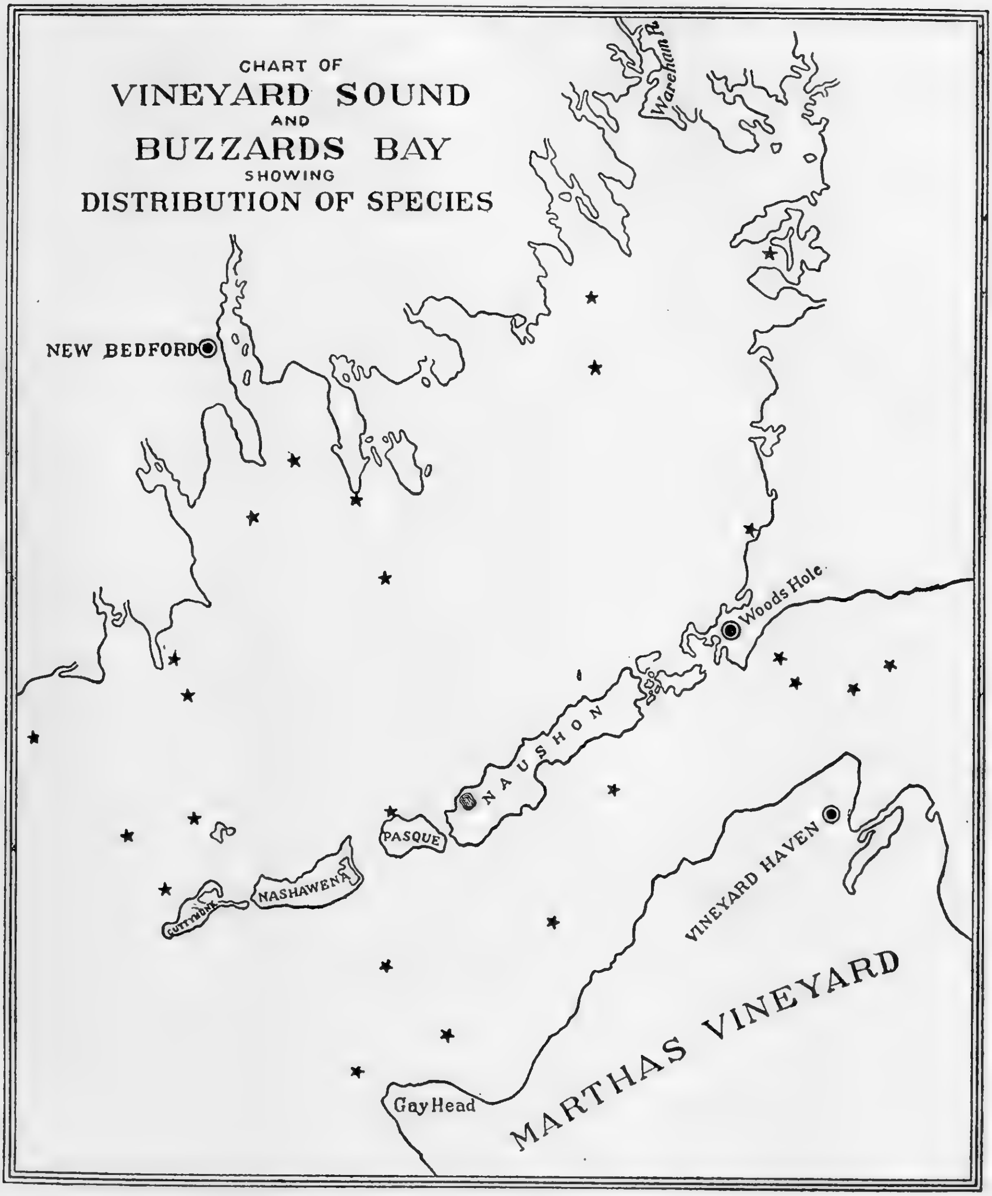

CHART 39.—Schizoporella biaperta.

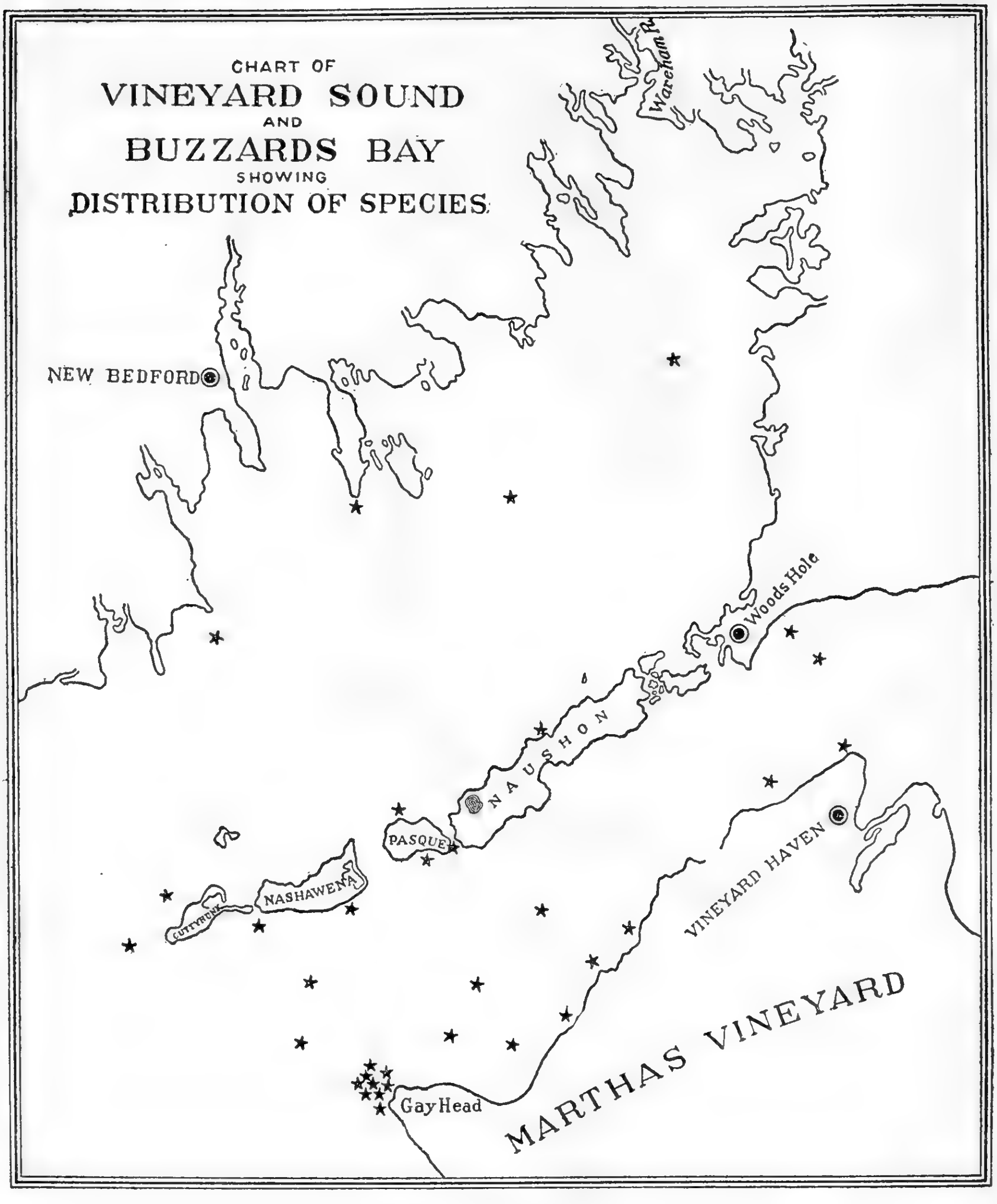

CHART 40.—Hippothoa hyalina.

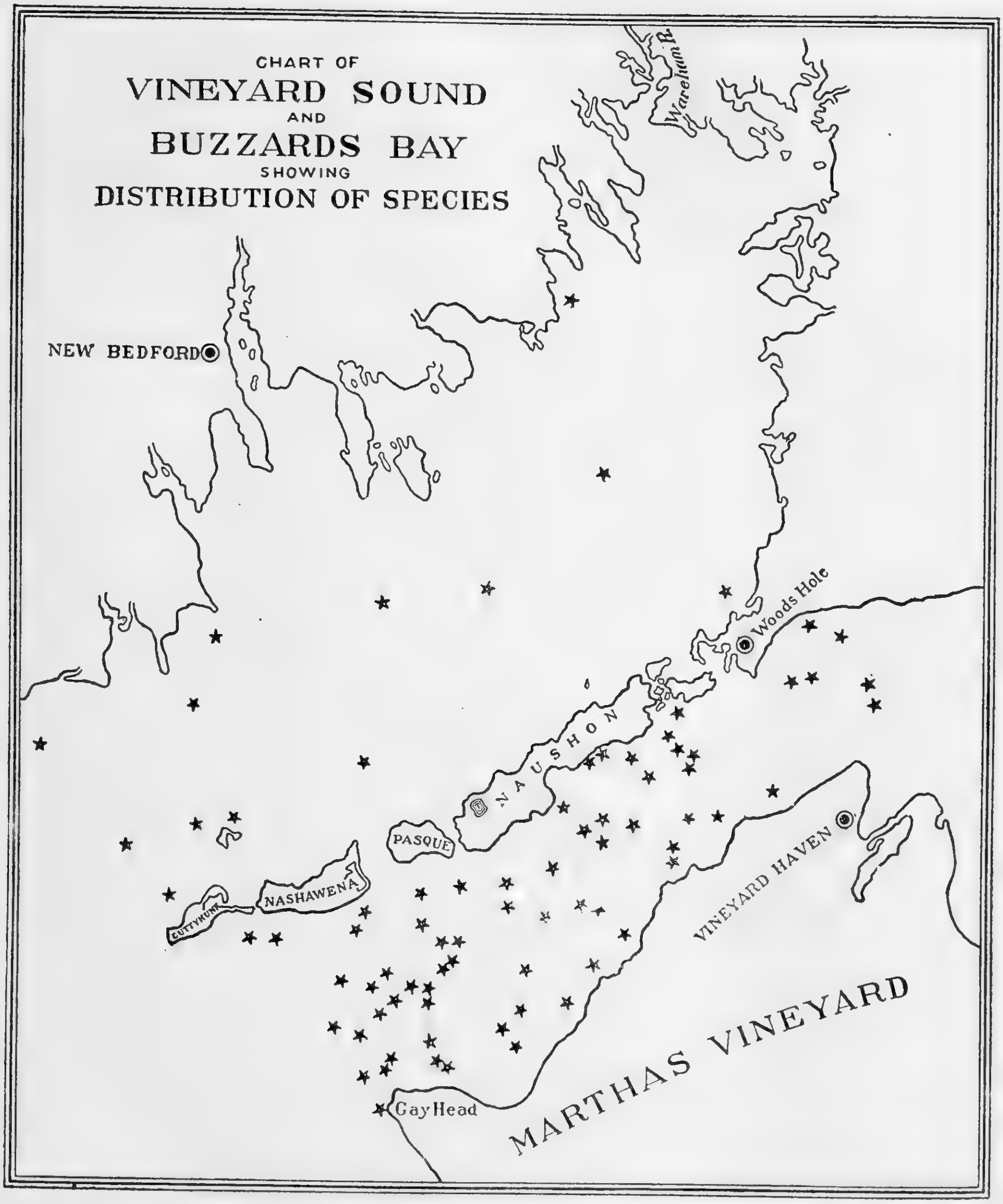

CHART 41.—Cellepora americana.

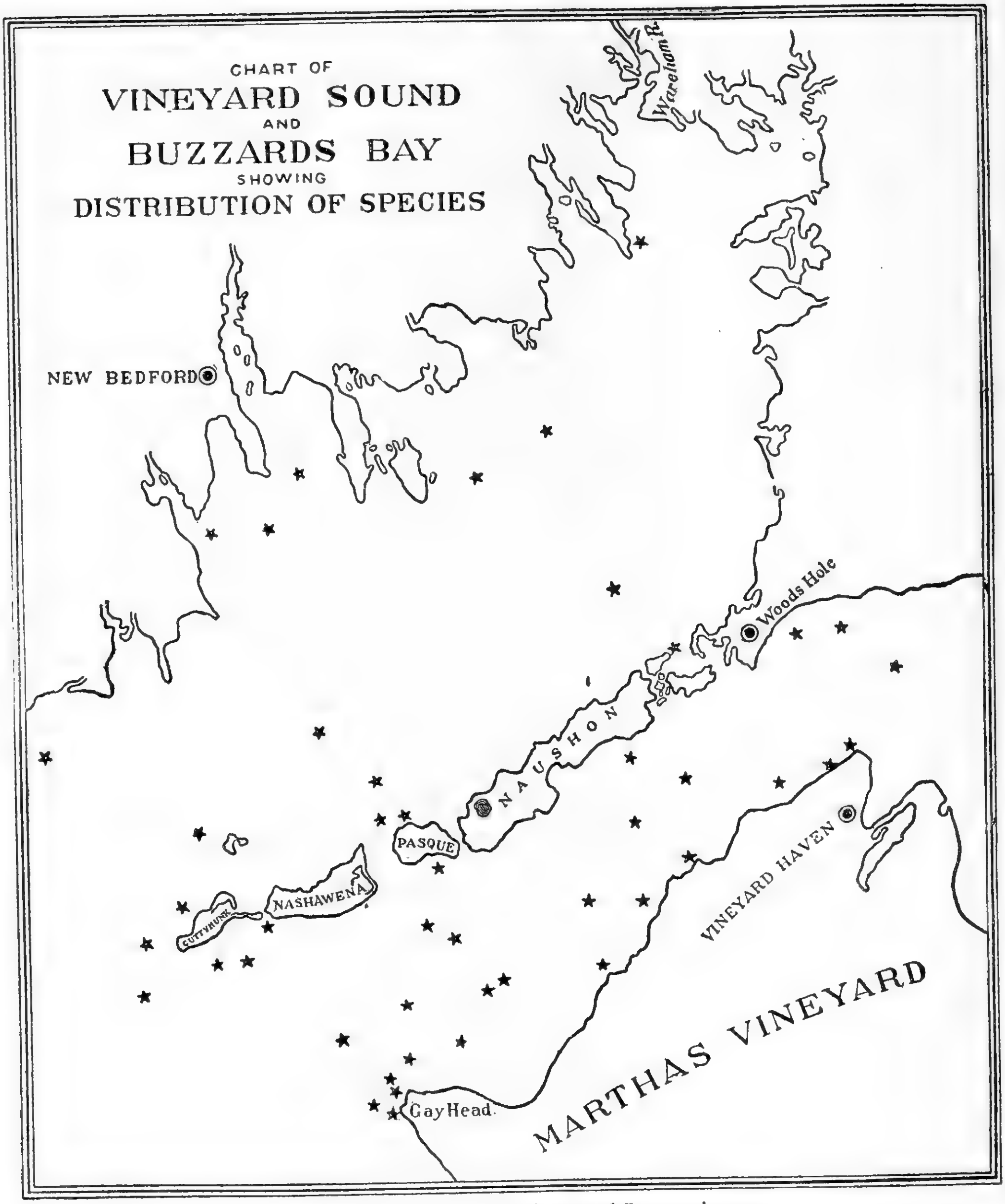

CHART 42.—Lepralia pallasiana and L. americana.

Owing to a confusion of the records, the distribution of these two species has been plotted upon a single chart.

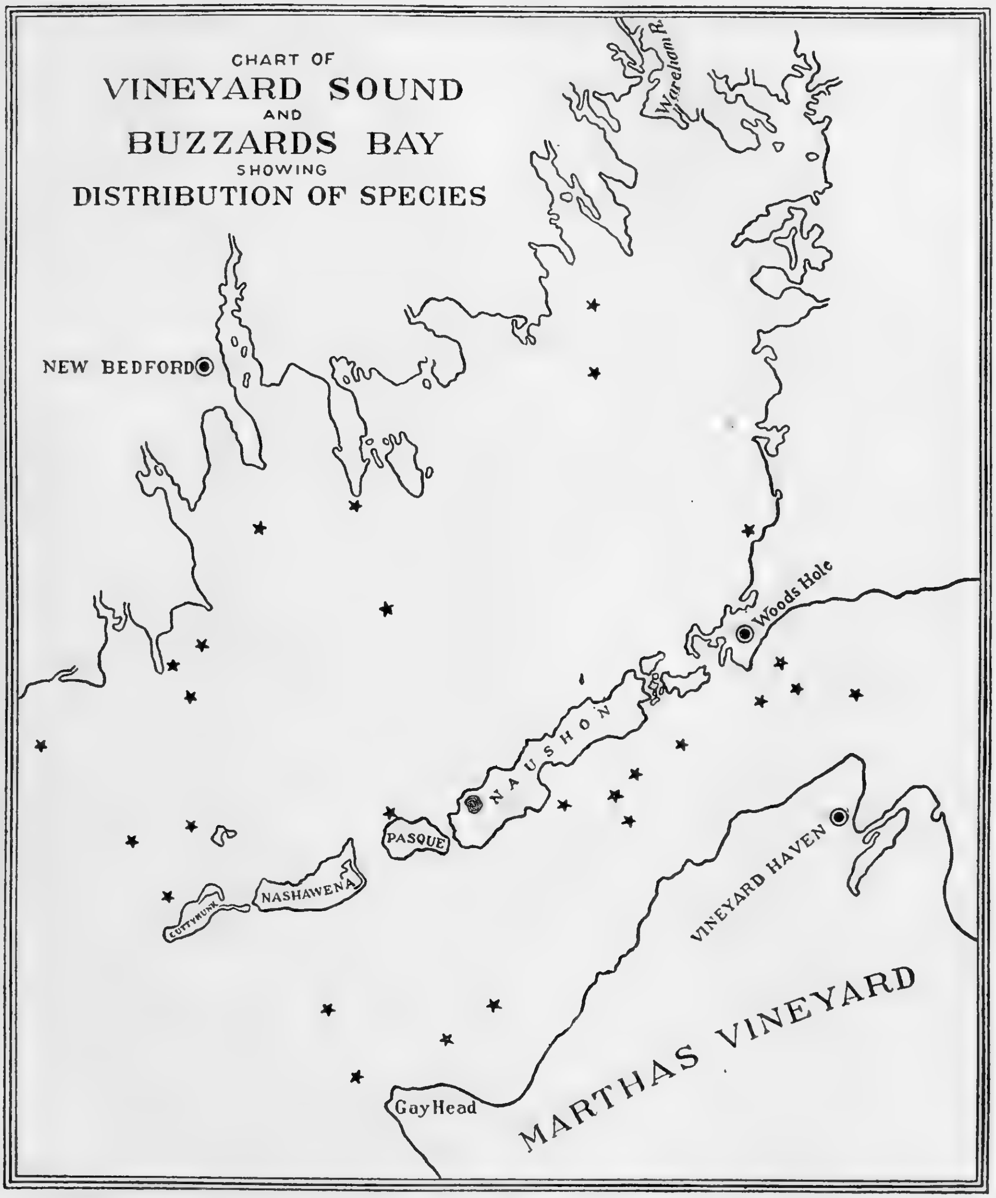

CHART 43.—Lepralia pertusa.

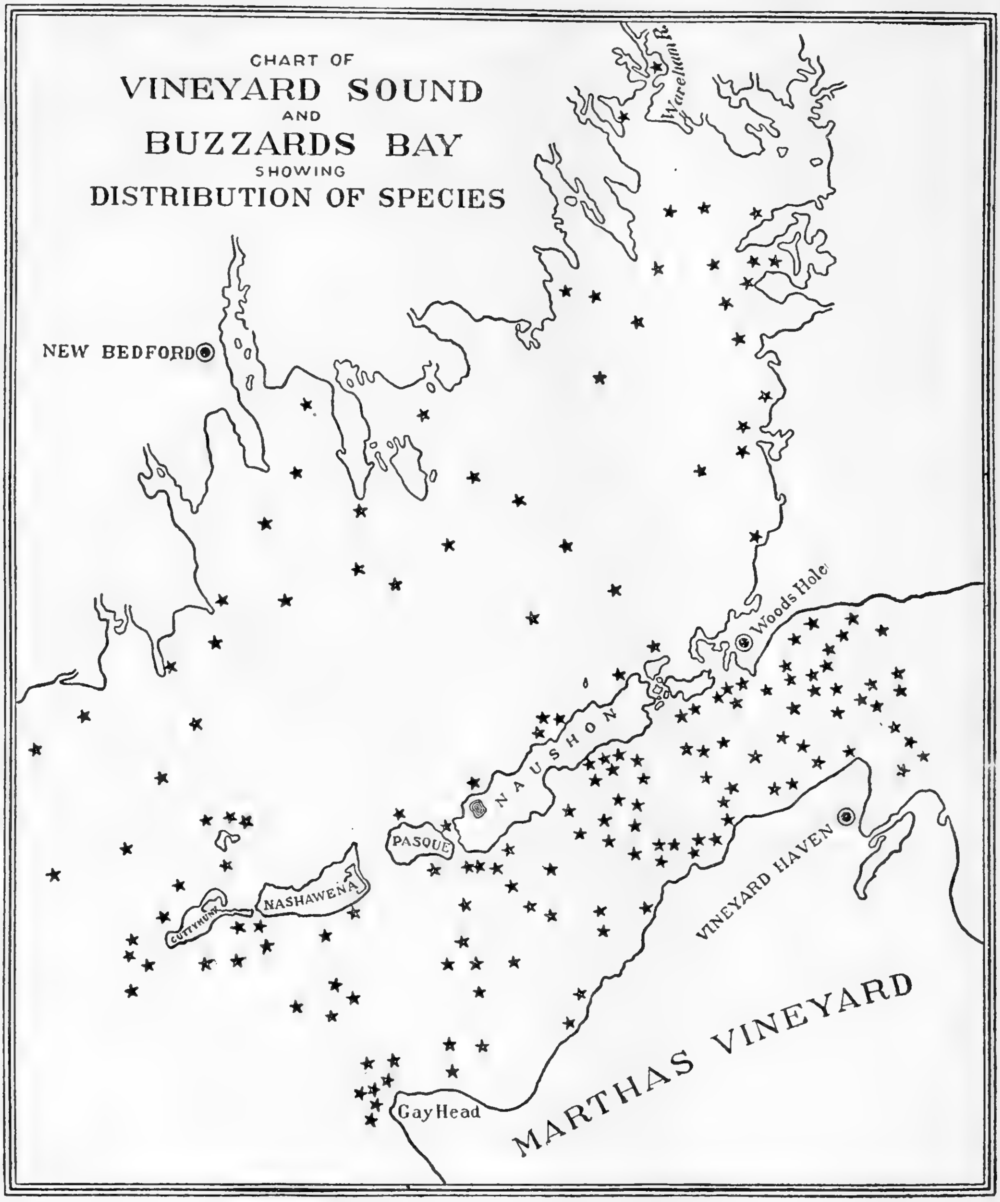

CHART 44.—Smittia trispinosa nitida.

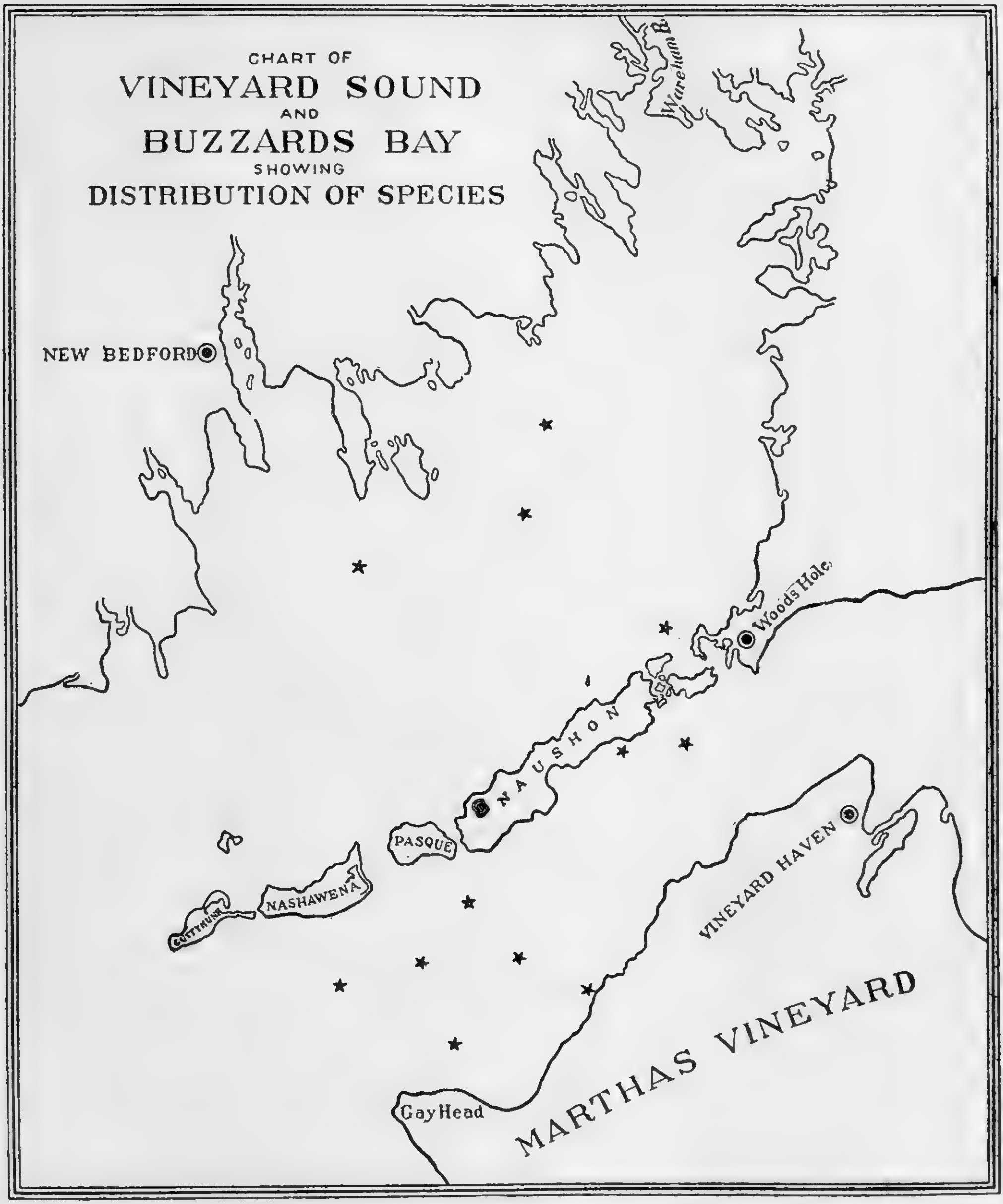

CHART 45.—Bowerbankia gracilis.

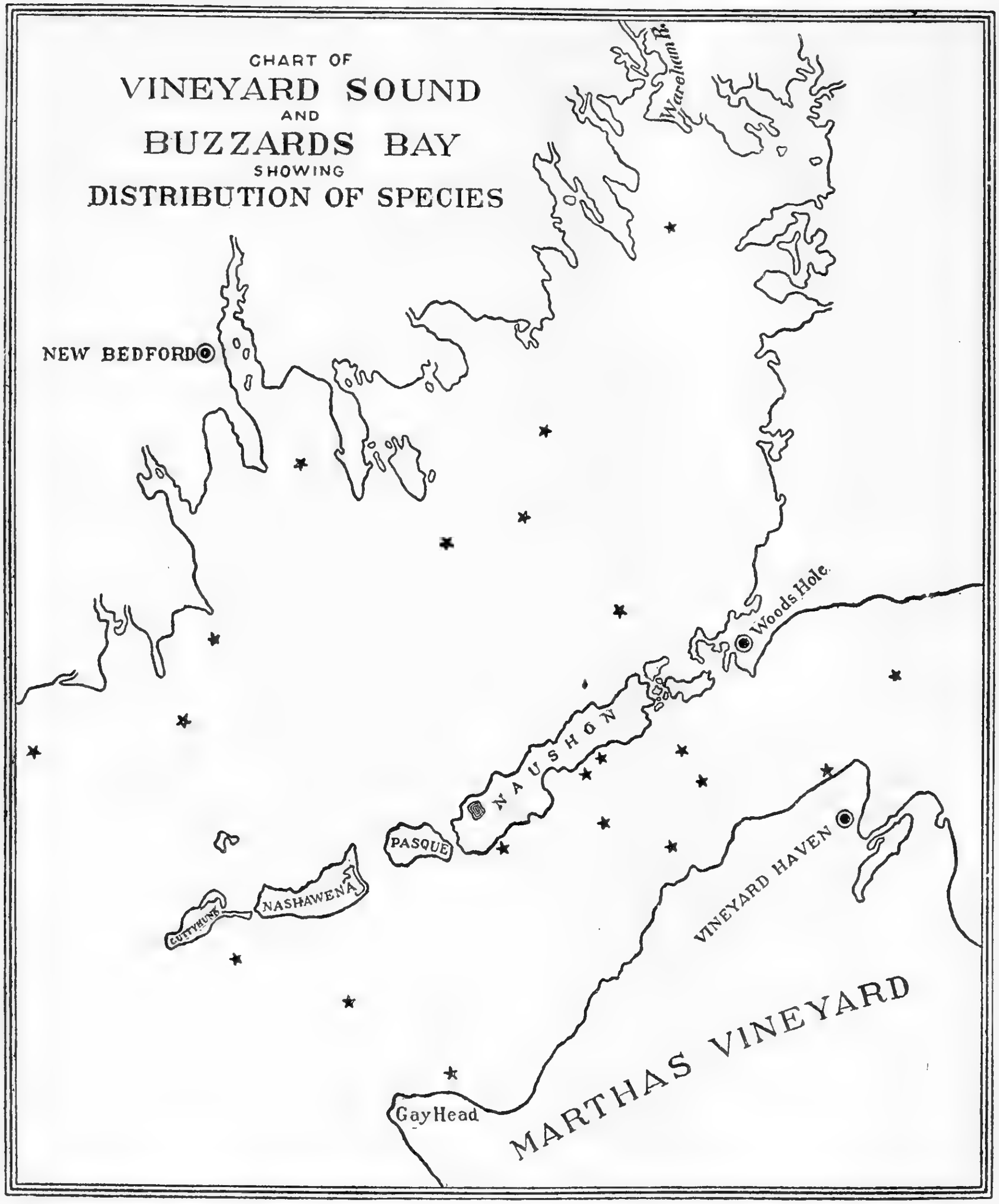

CHART 46.—Hippuraria armata.

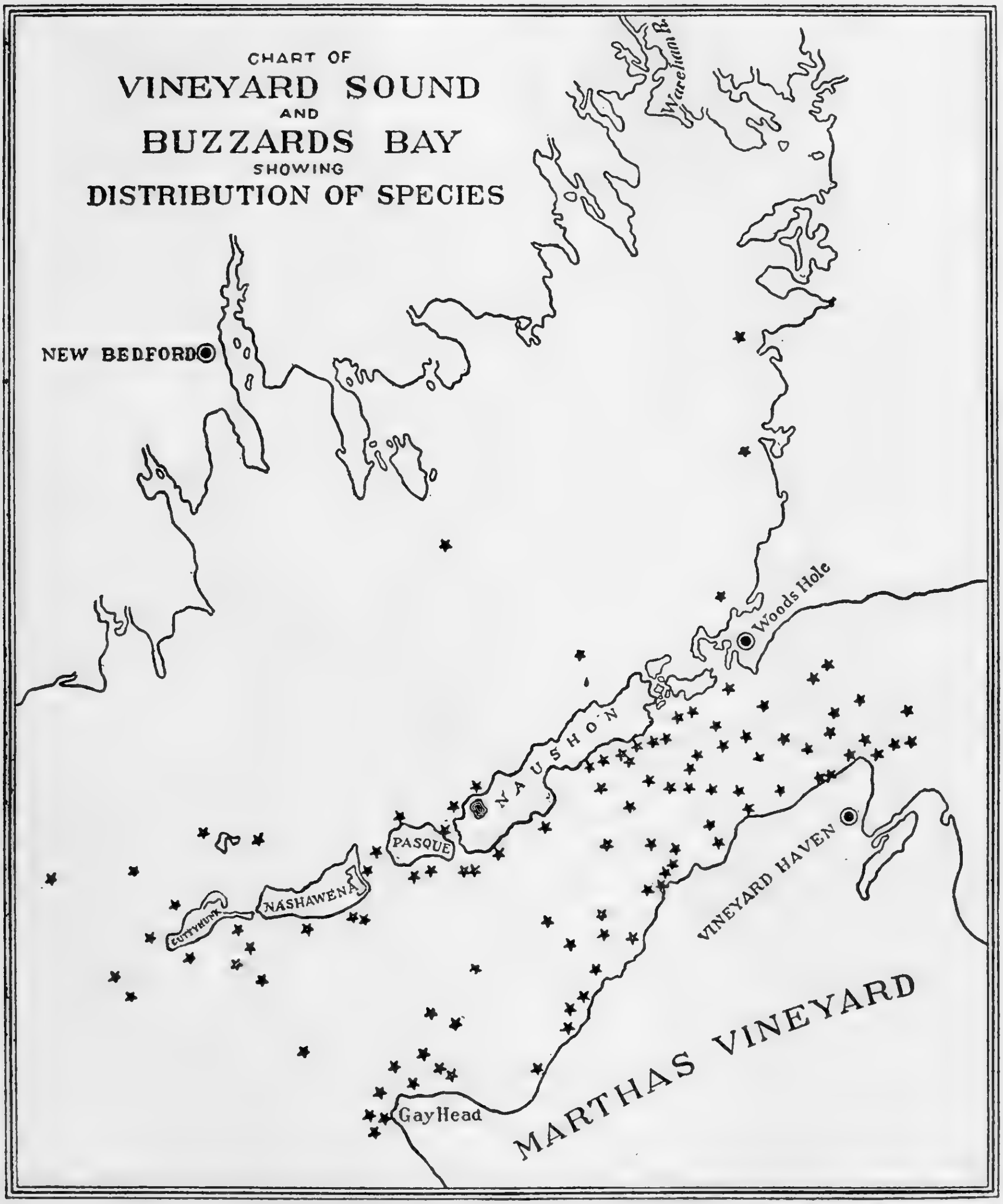

CHART 47.—Henricia sanguinolenta.

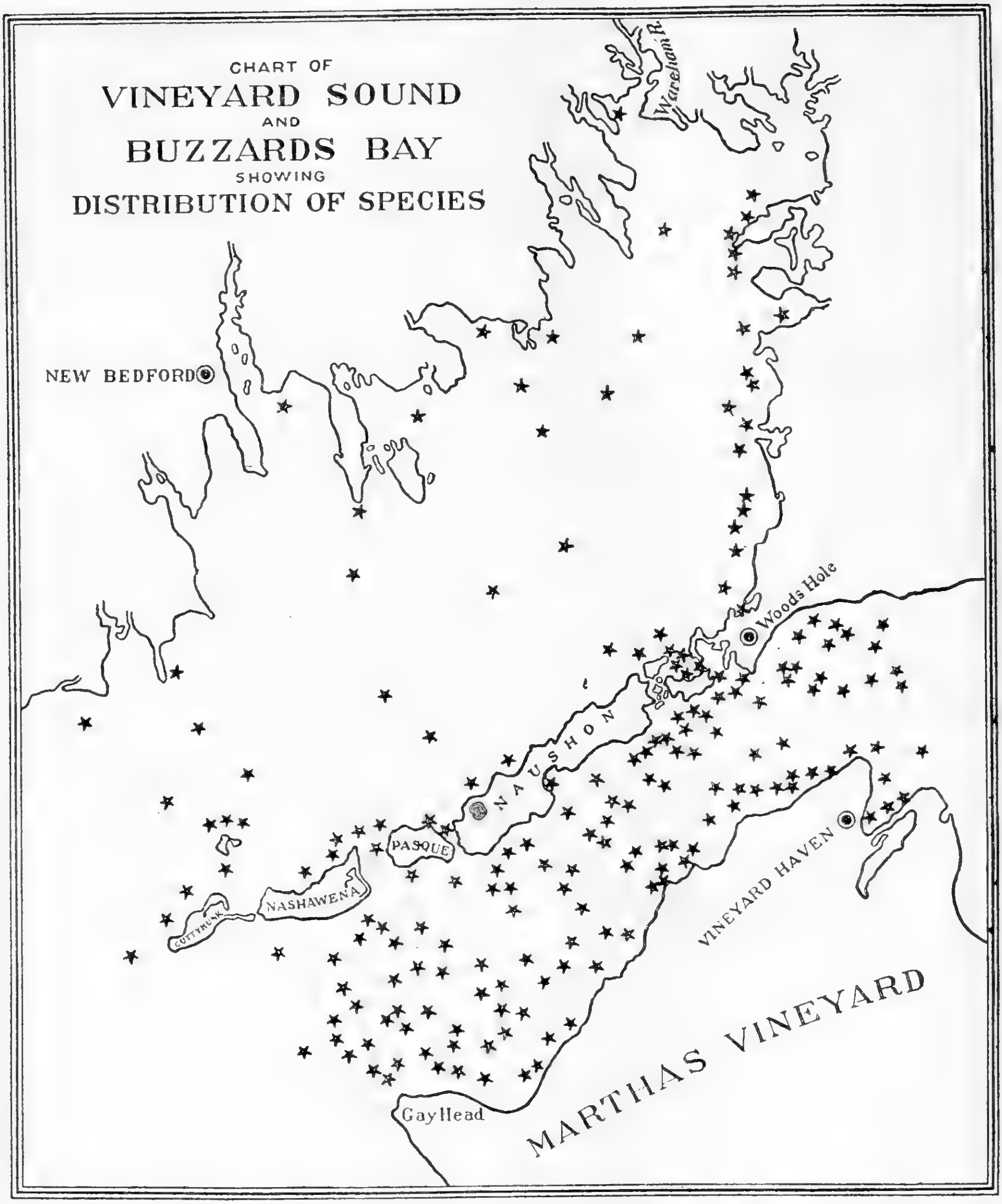

CHART 48.—Asterias forbesi.

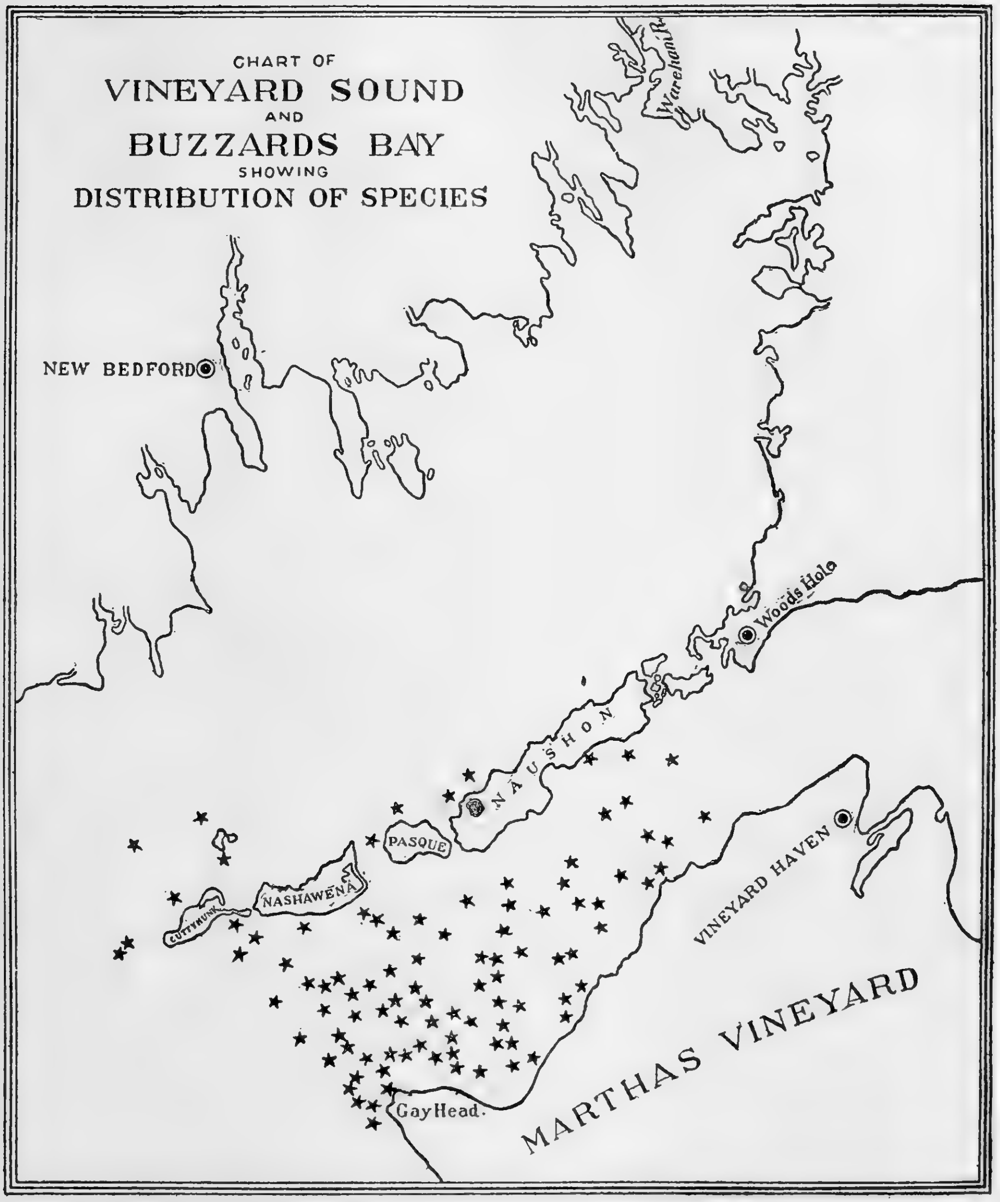

CHART 49.—Asterias vulgaris.

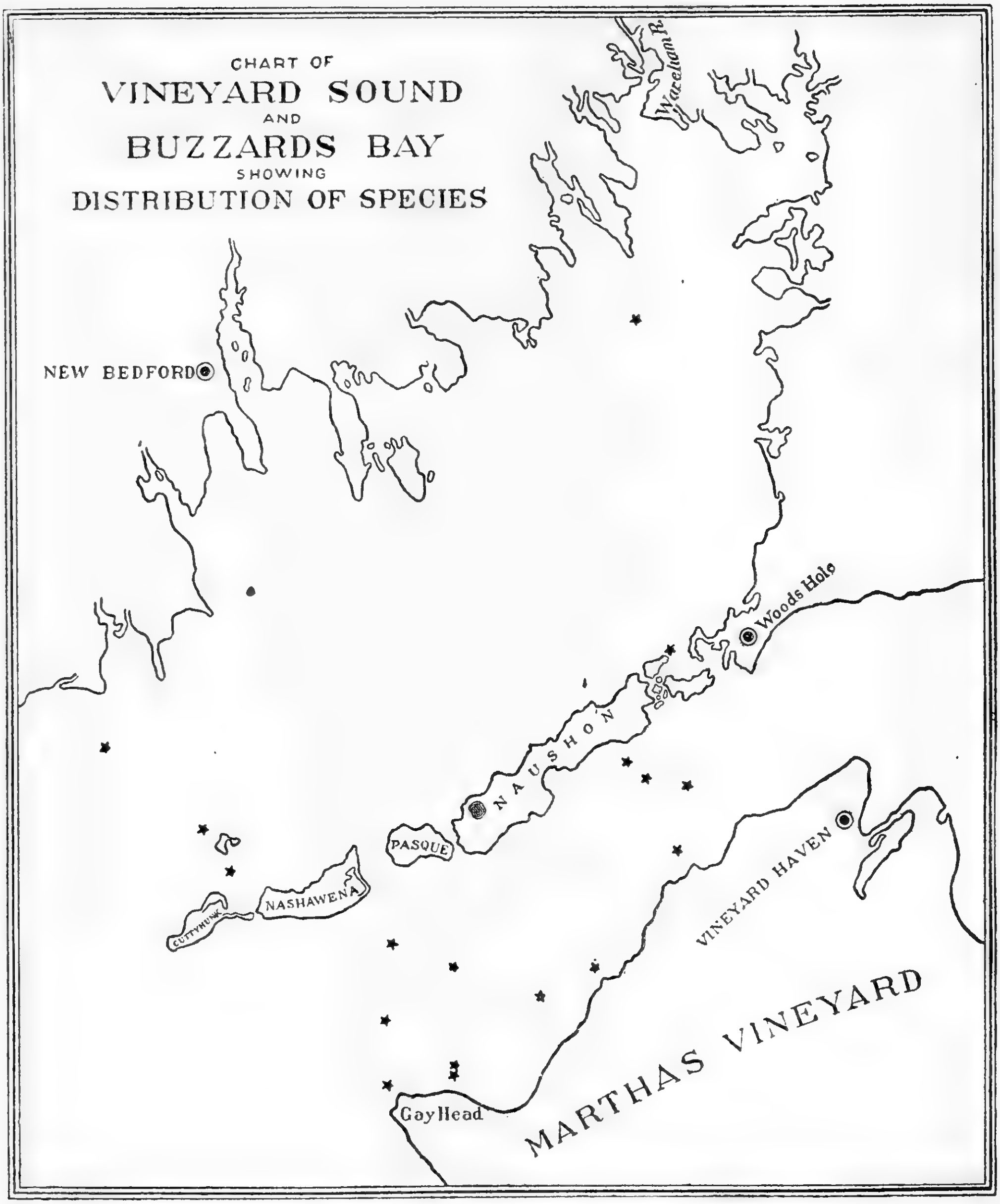

CHART 50.—Amphipholis squamata.

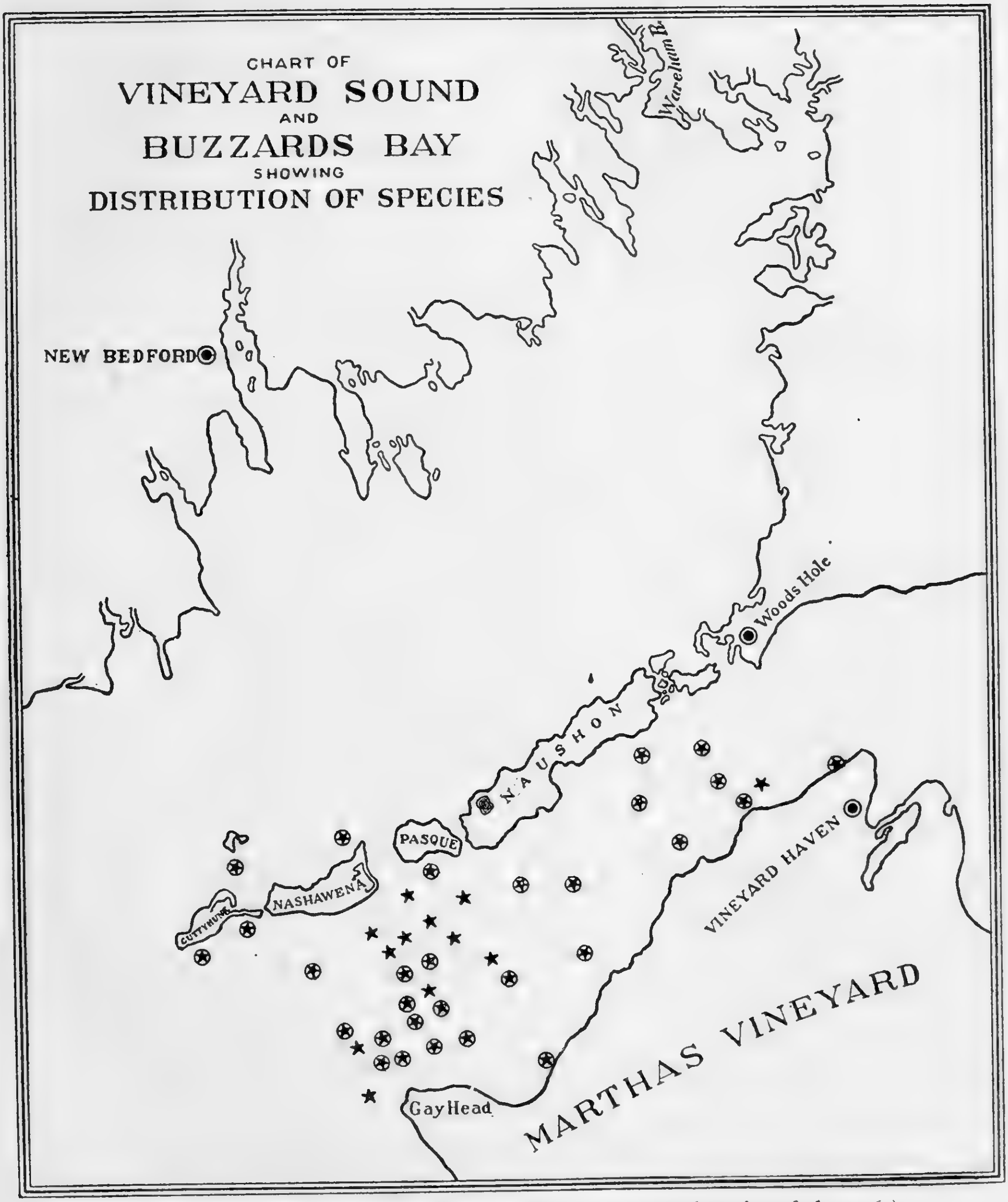

CHART 51.—Strongylocentrotus droebachiensis. (See explanation of chart 26.)

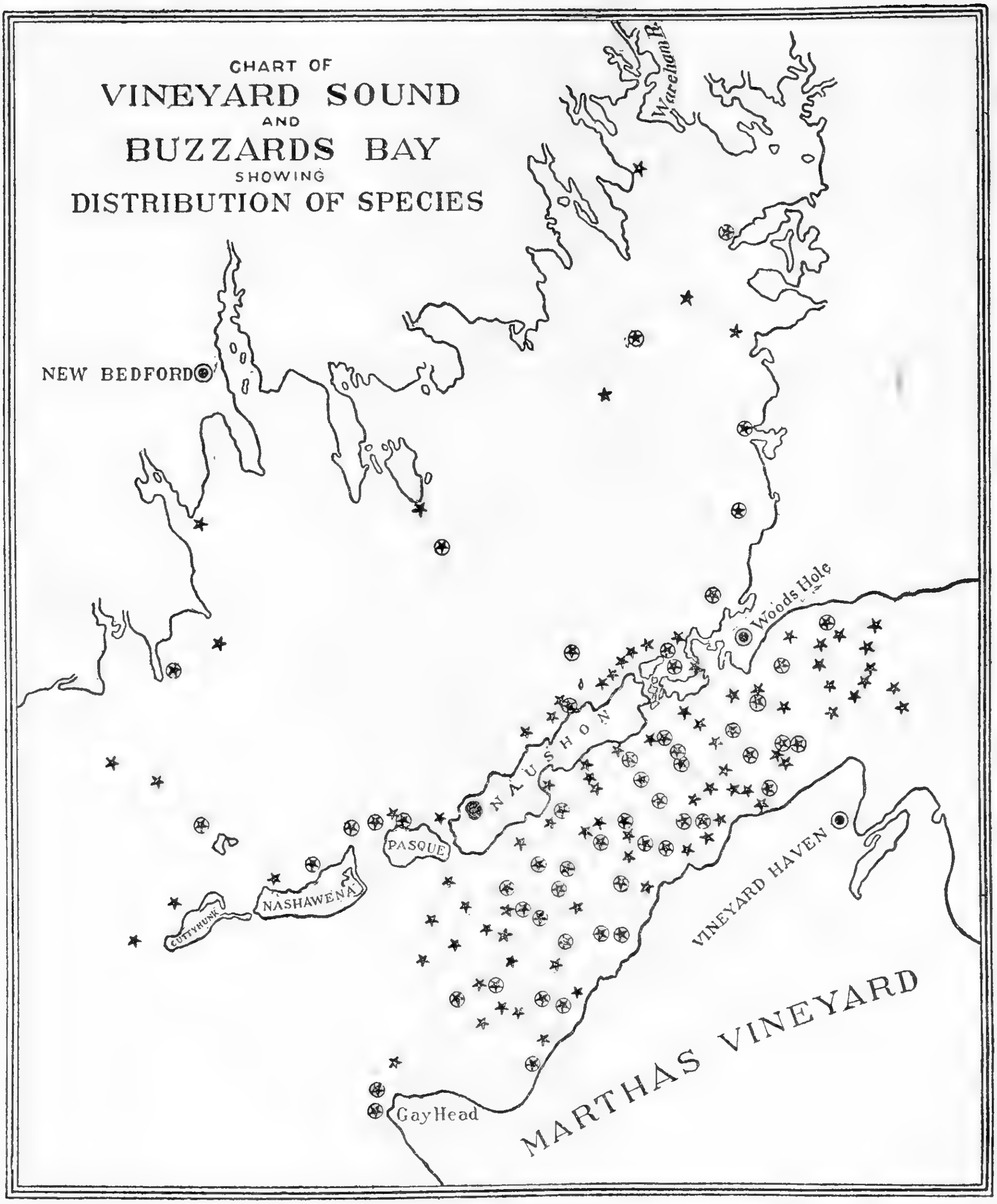

CHART 52.—Arbacia punctulata. (See explanation of chart 26.)

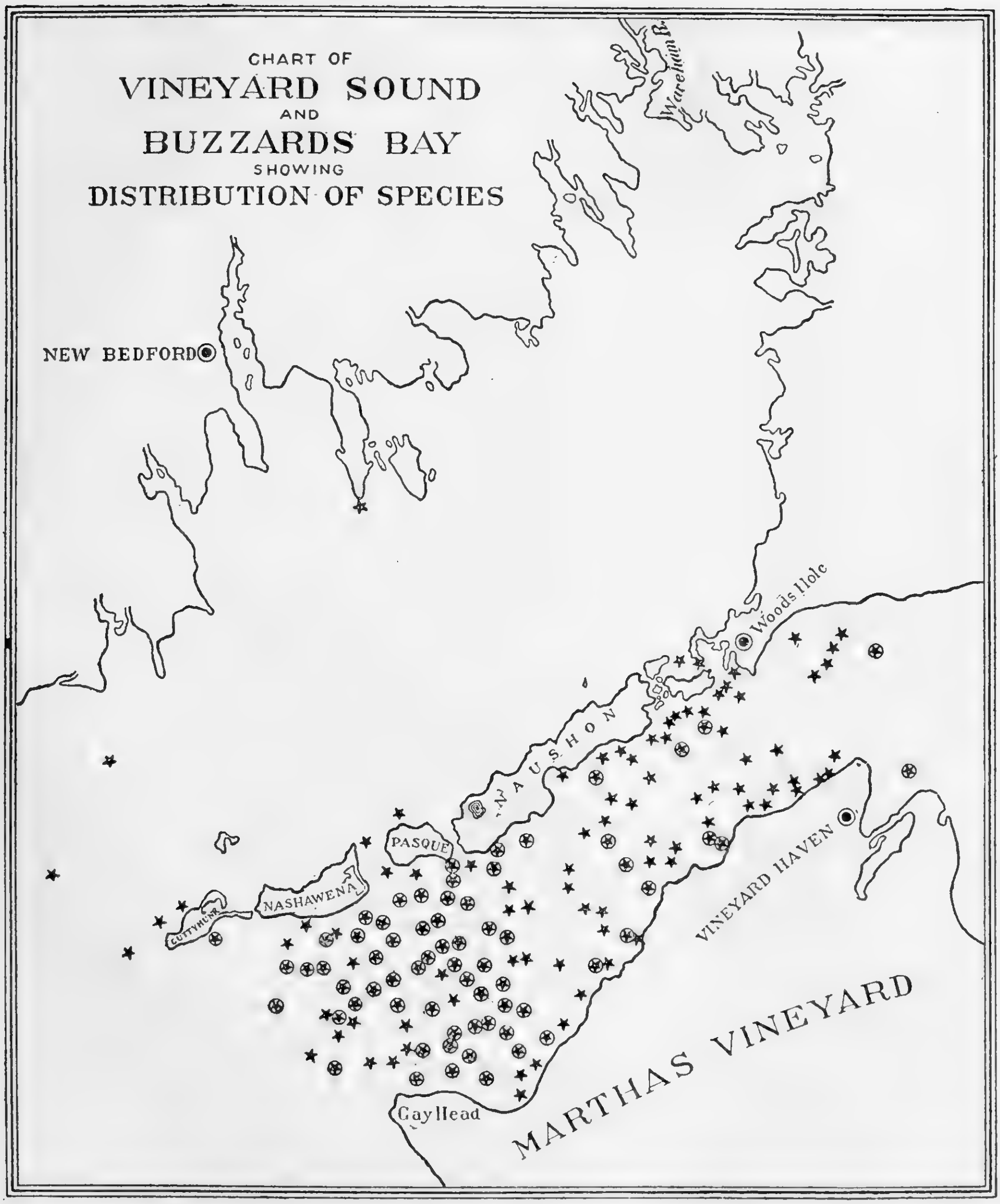

CHART 53.—Echinarachnius parma. (See explanation of chart 26.)

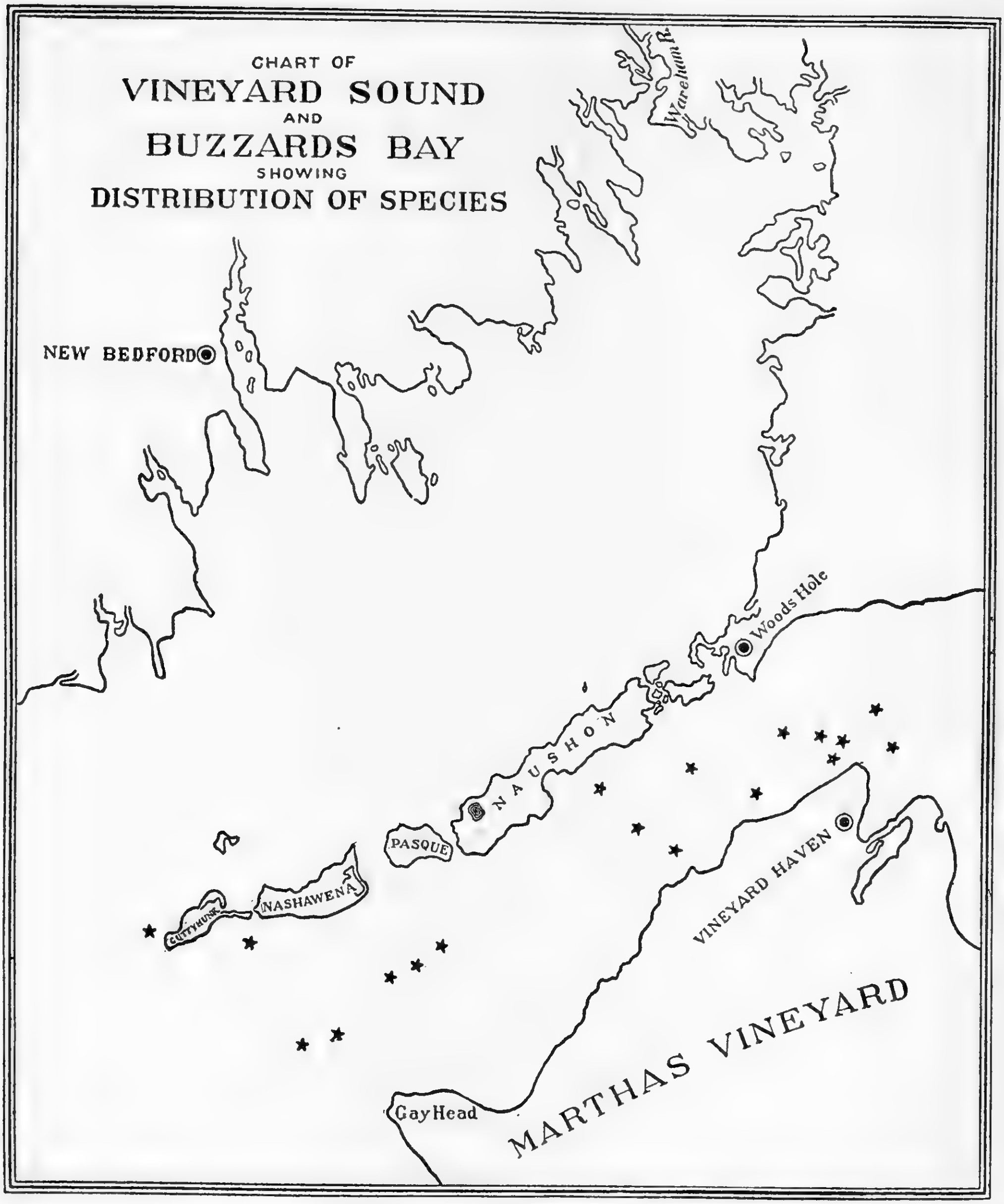

CHART 54.—Eulalia annulata.

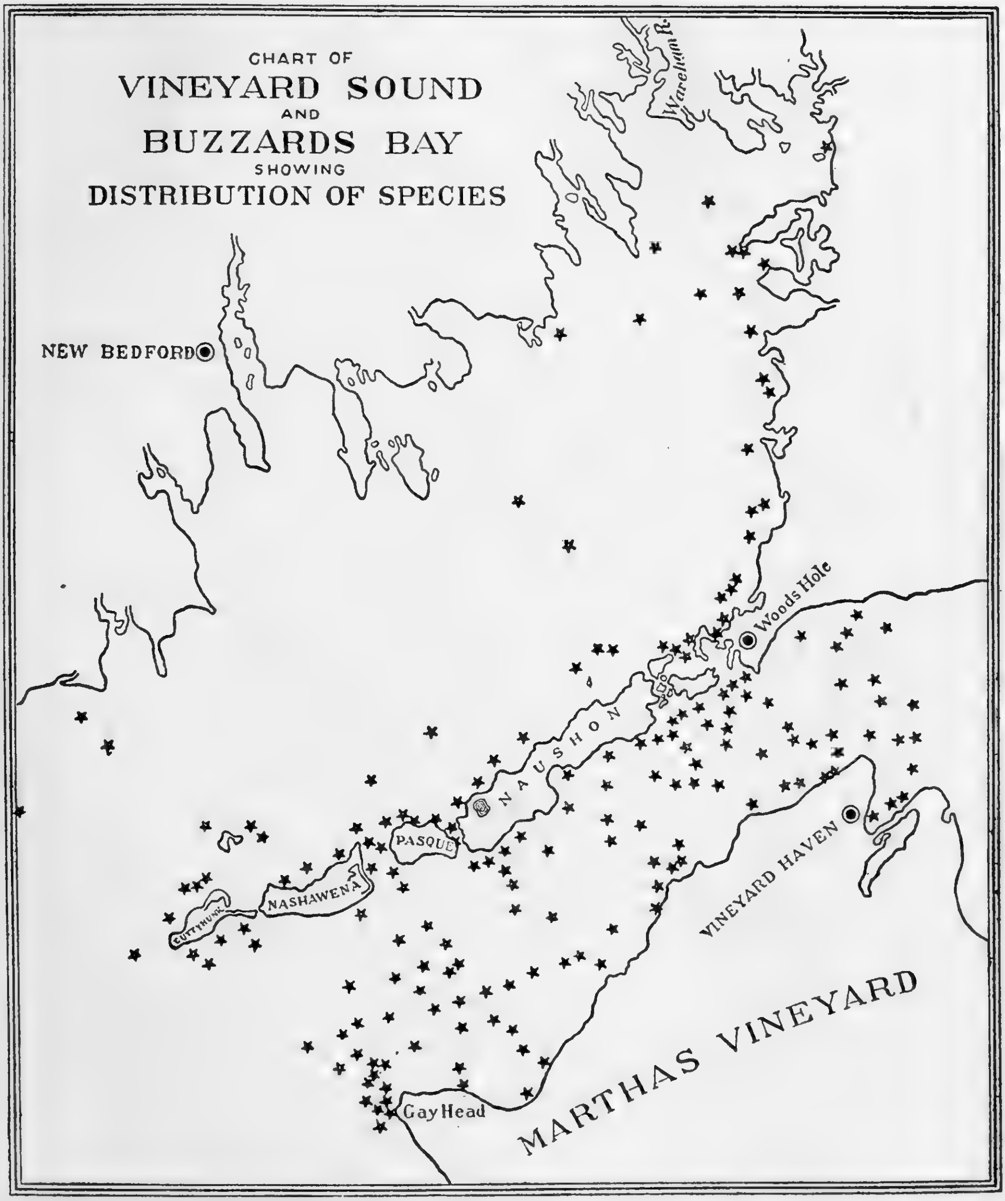

CHART 55.—Harmothoë imbricata.

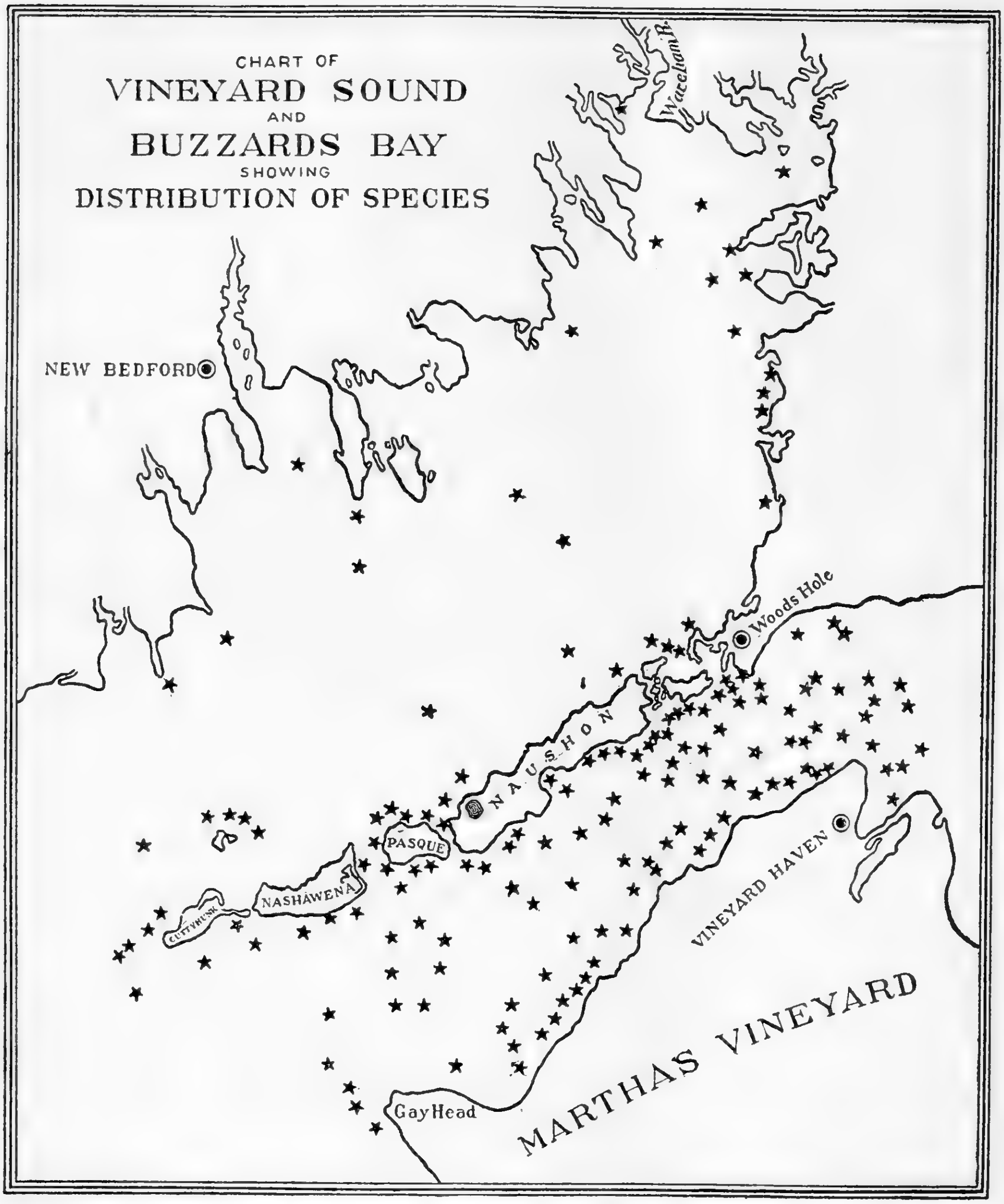

CHART 56.—Lepidonotus squamatus.

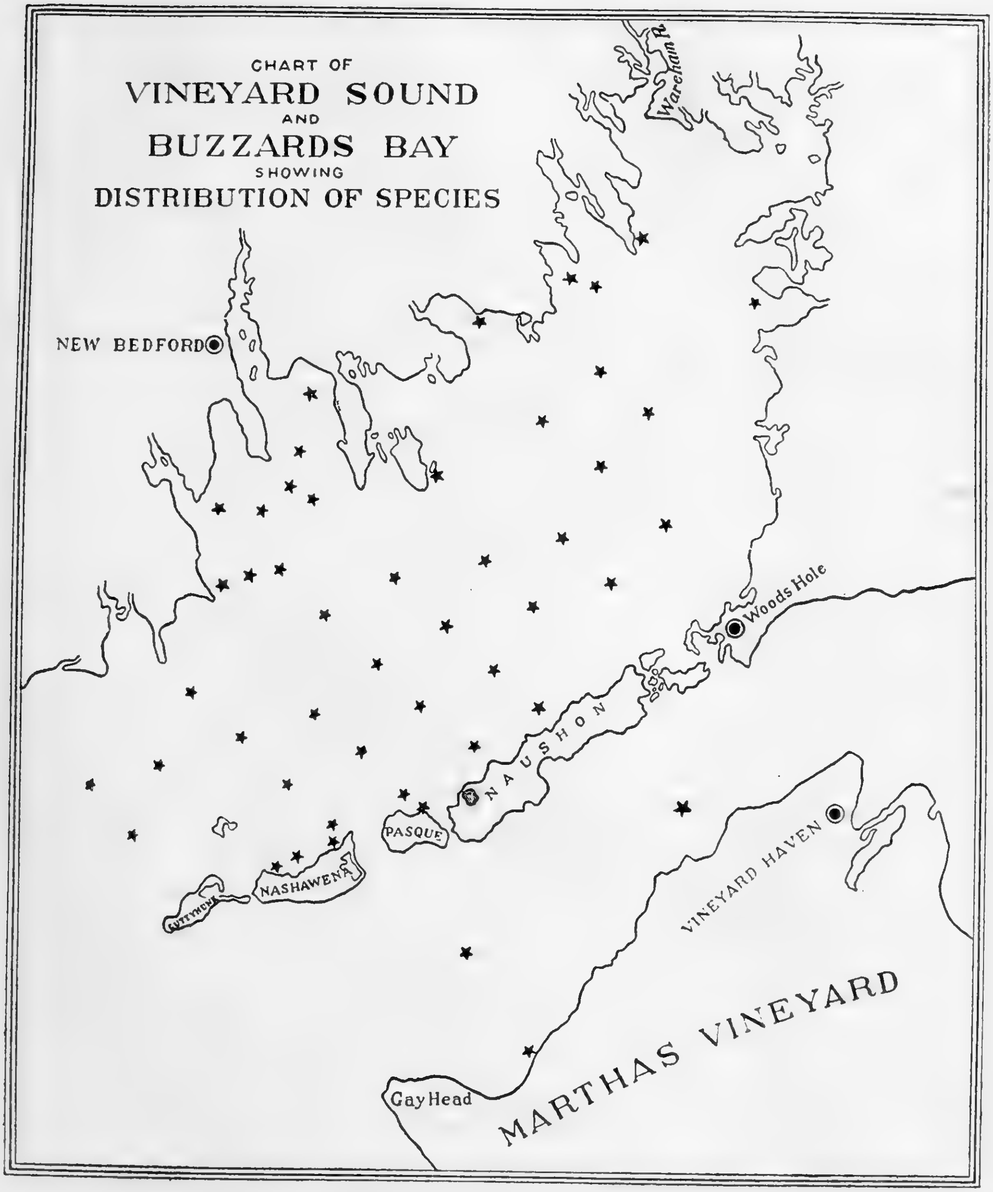

CHART 57.—Nephthys incisa.

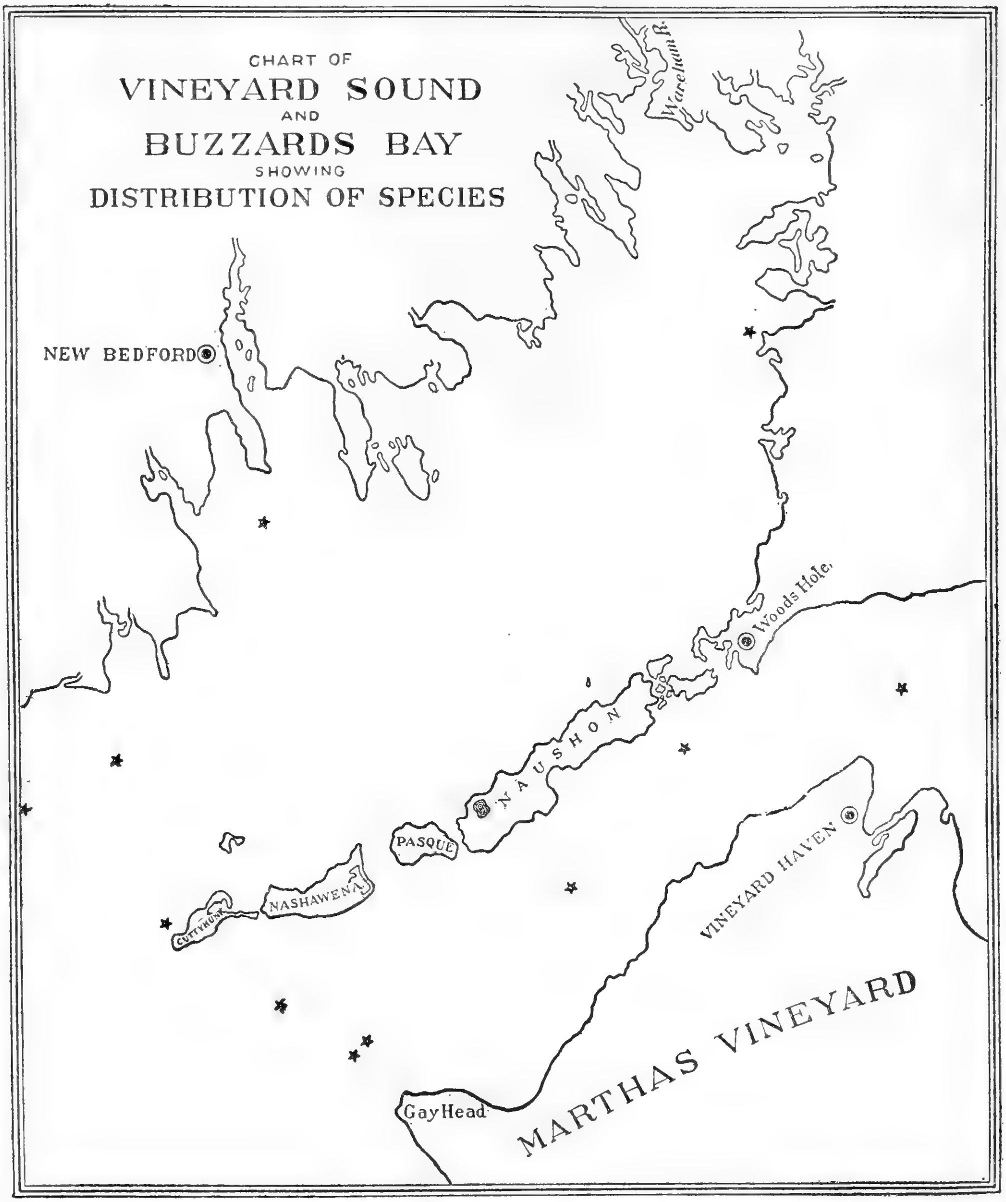

CHART 58.—Nephthys bucera.

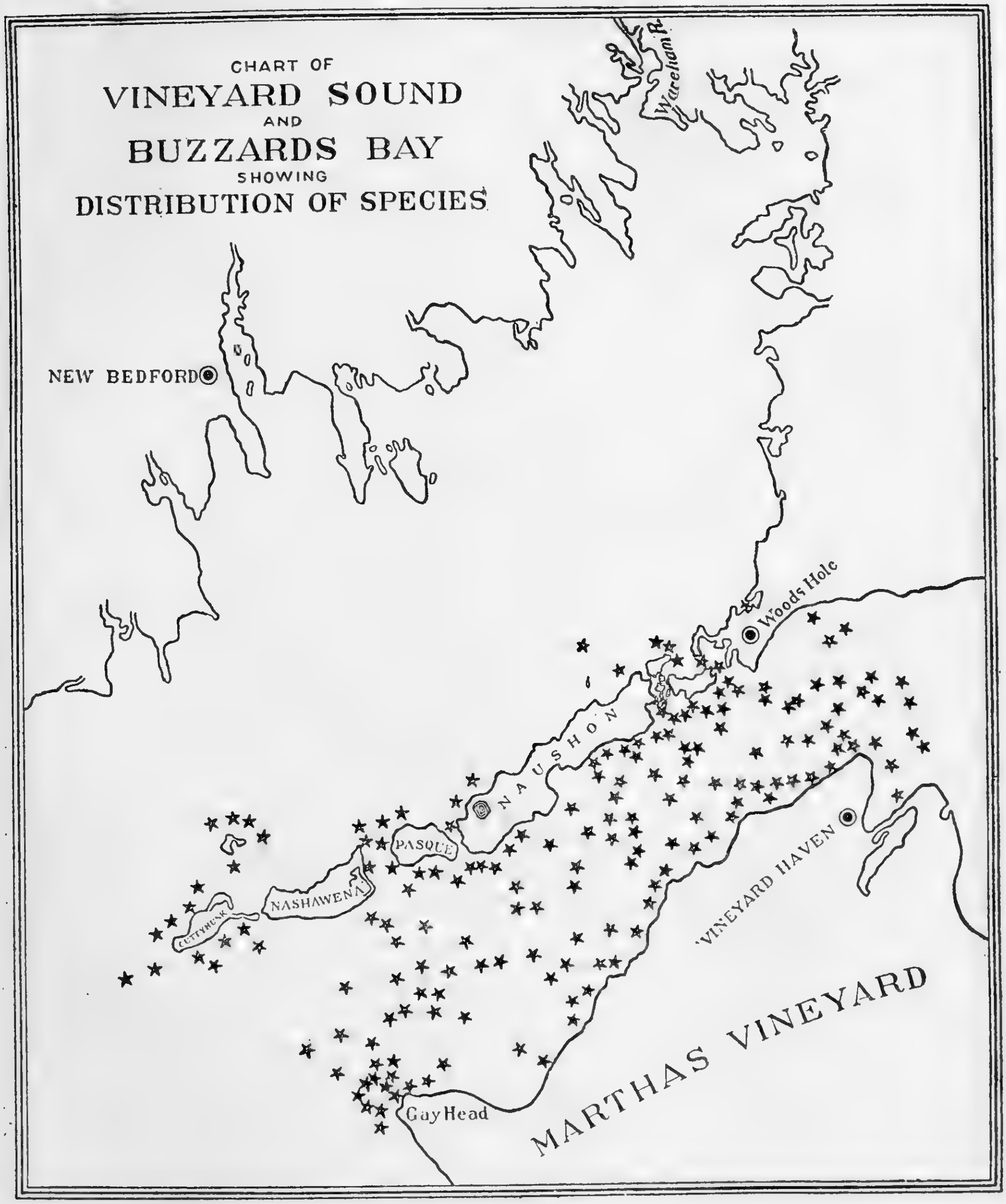

CHART 59.—Nereis pelagica.

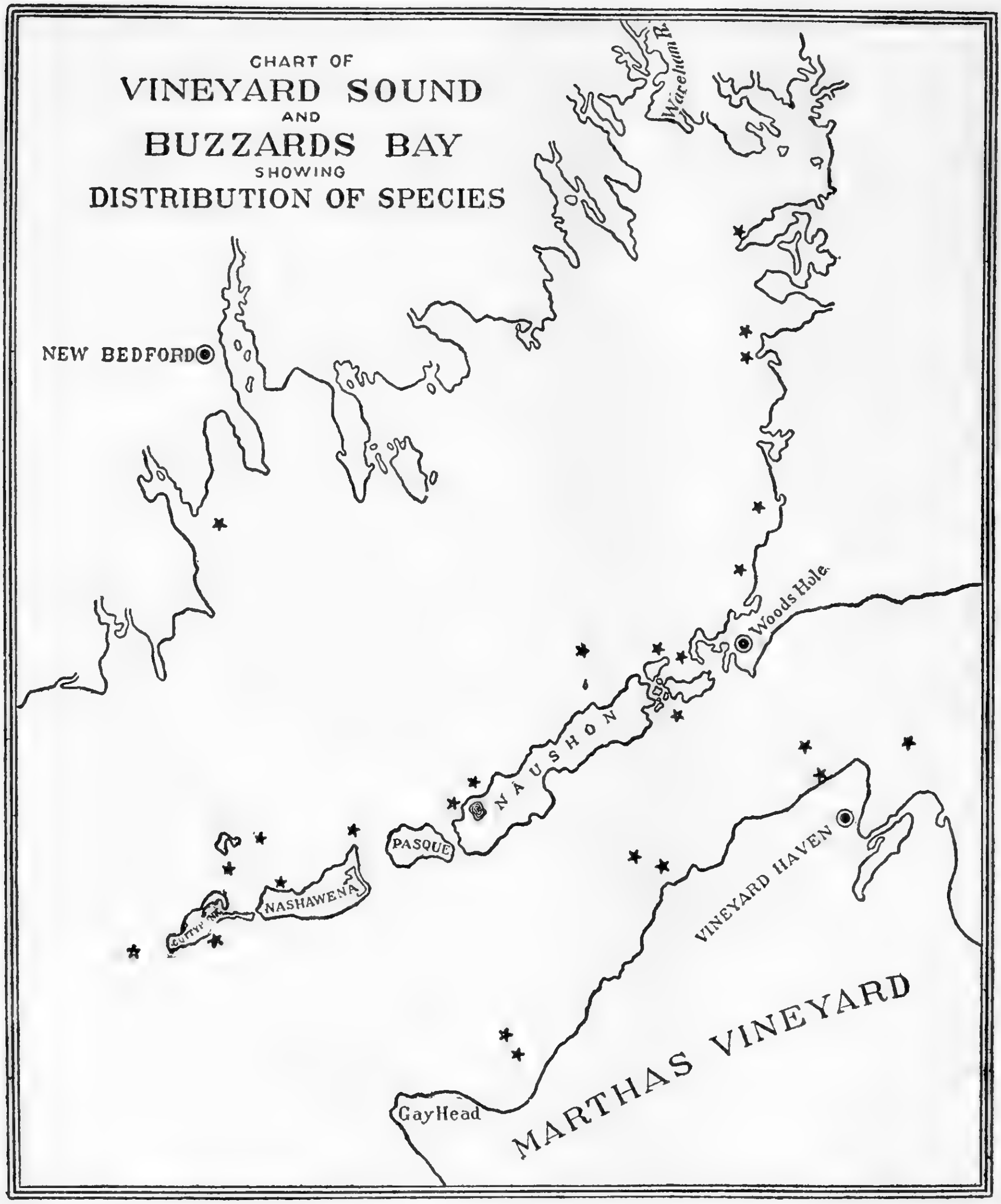

CHART 60.—Platynereis megalops.

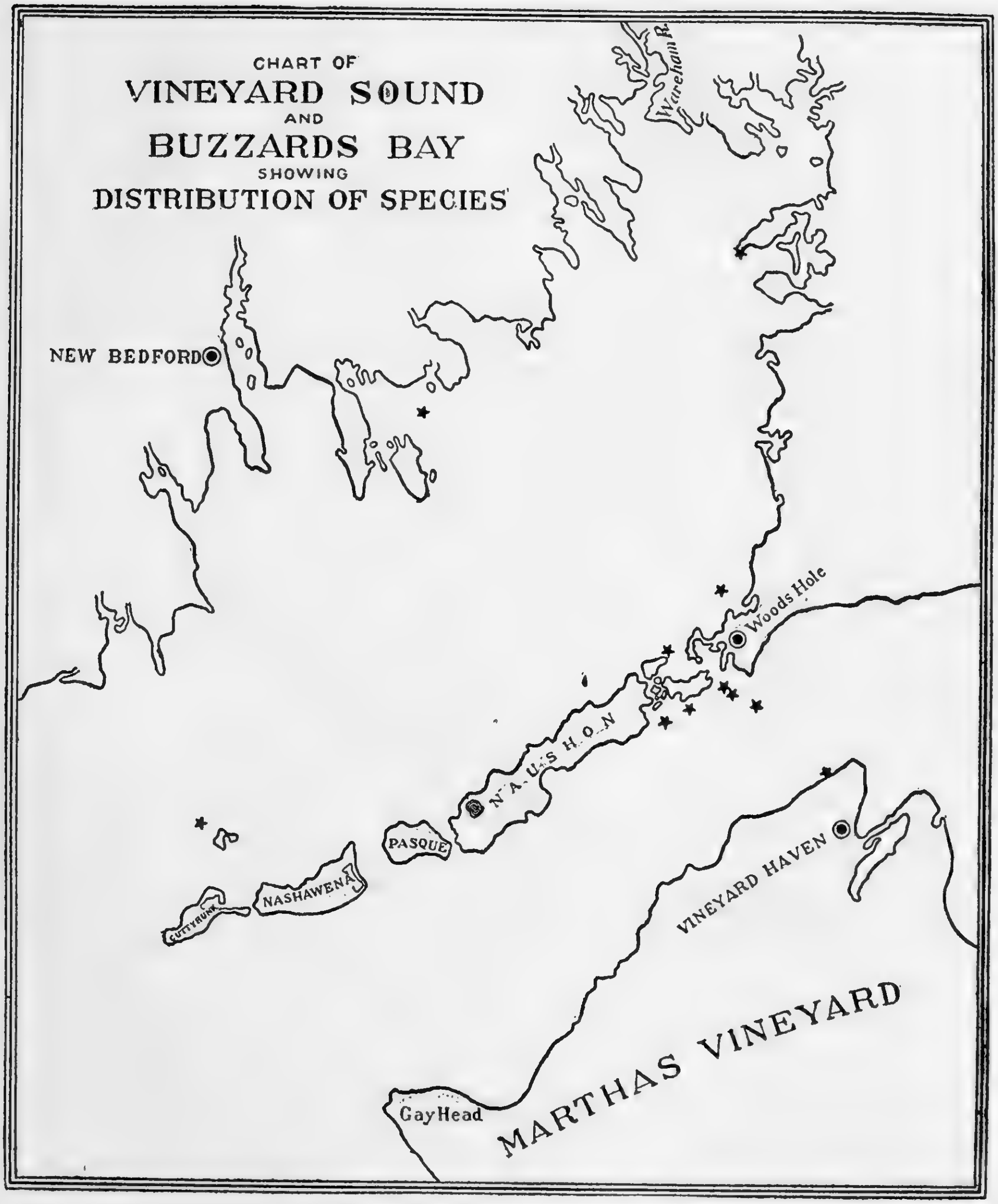

CHART 61.—Marphysa leidyi.

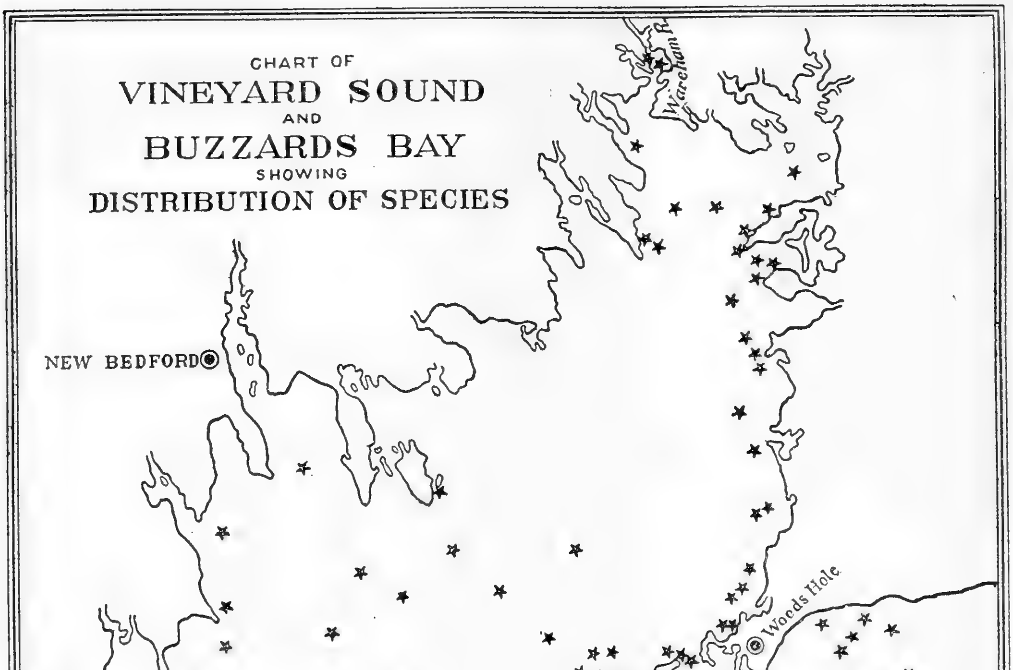

CHART 62.—Diopatra cuprea (tubes only).

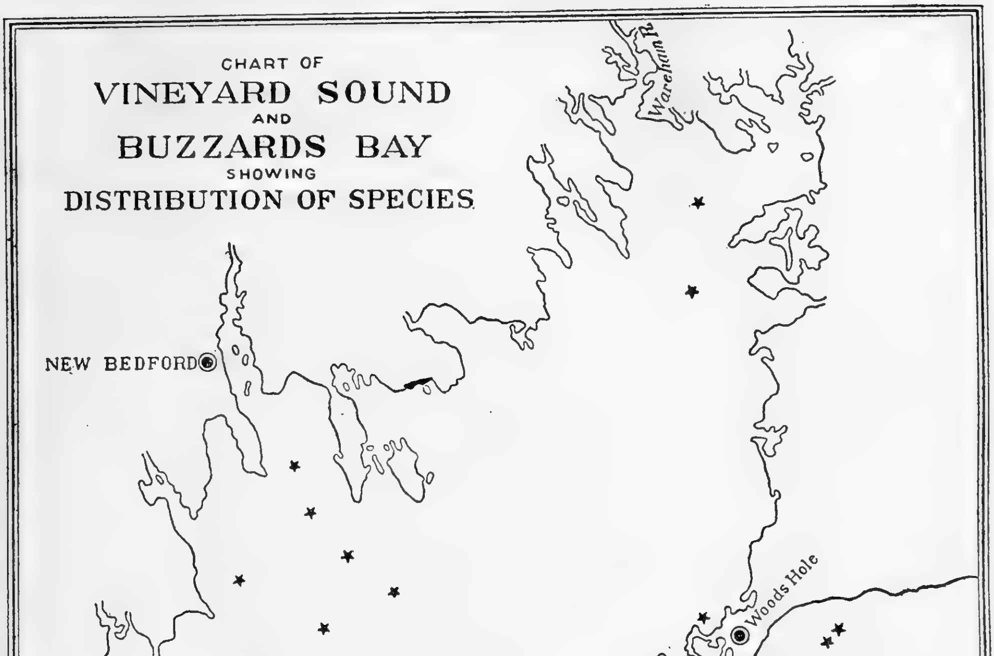

CHART 63.—Arabella opalina.

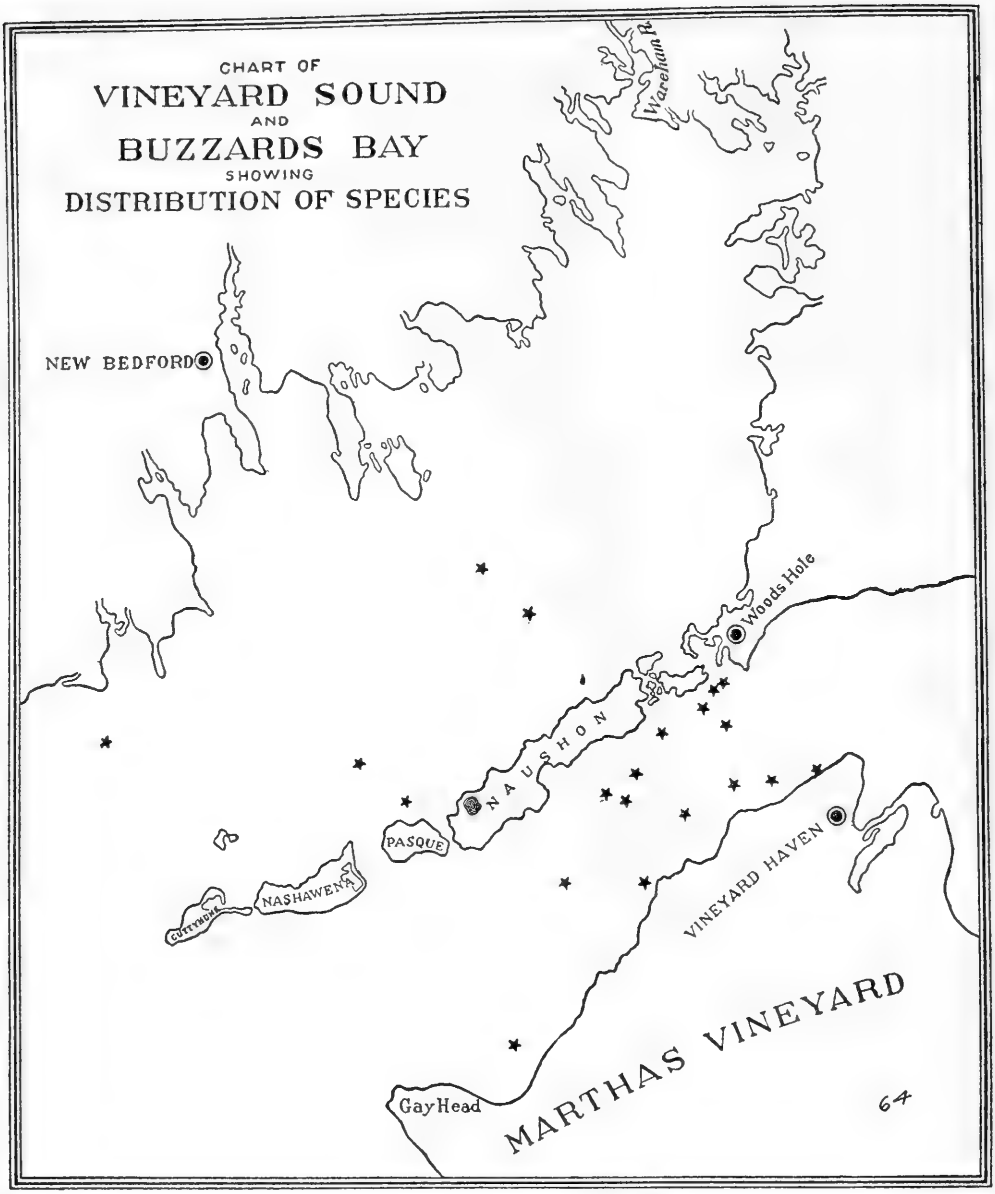

CHART 64.—Lumbrineris hebes.

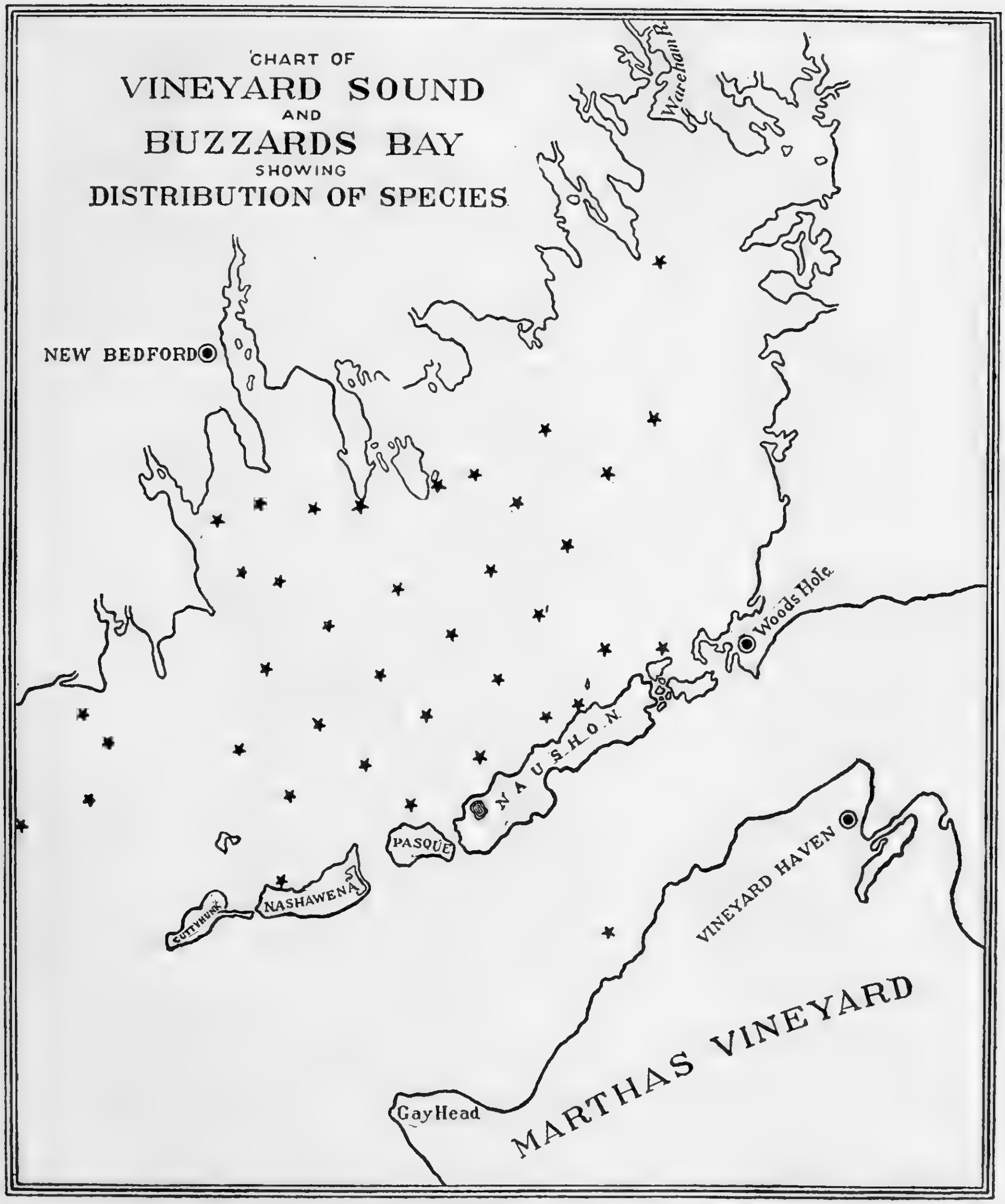

CHART 65.—Ninoë nigripes.

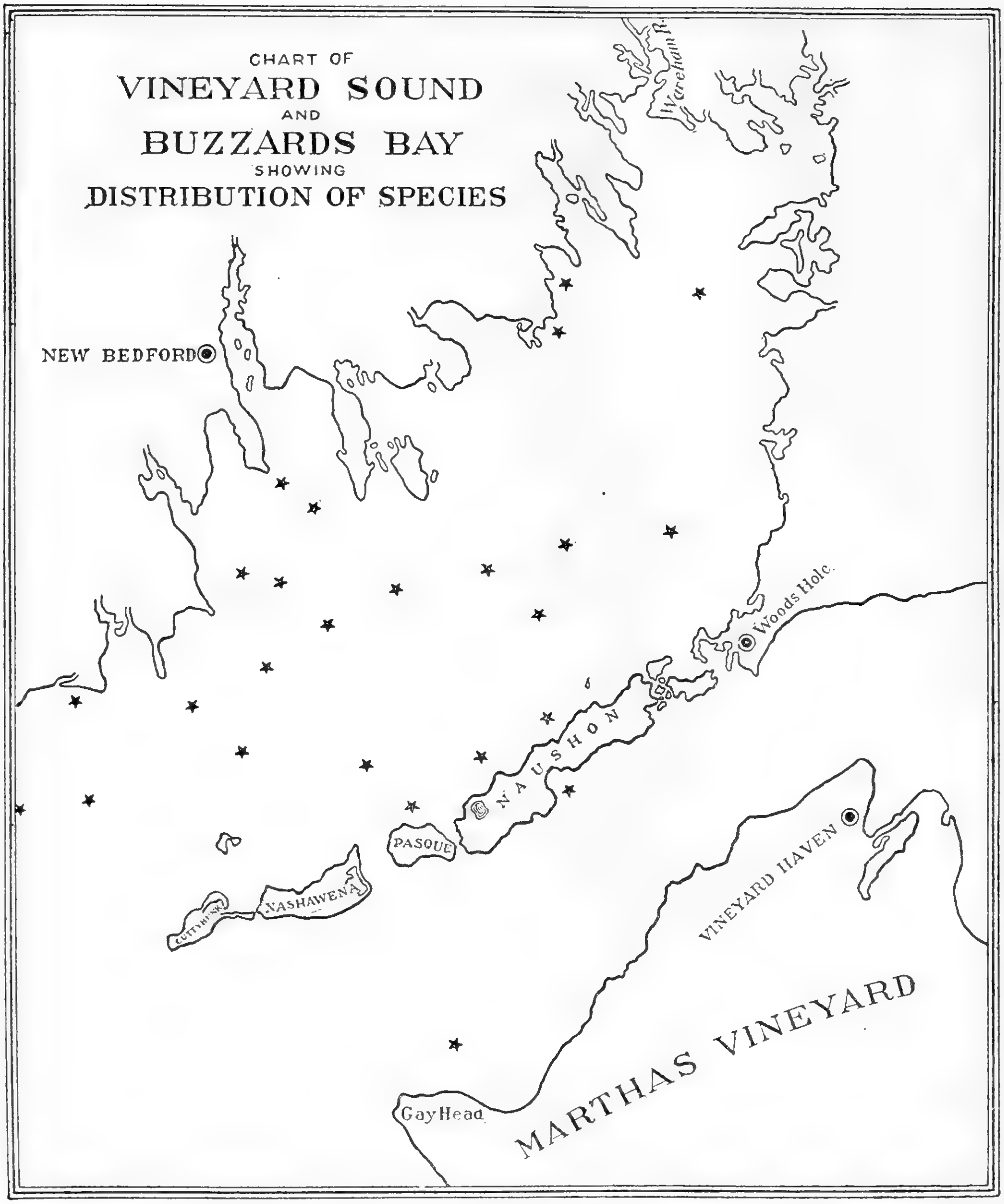

CHART 66.—Rhynchobolus americanus.

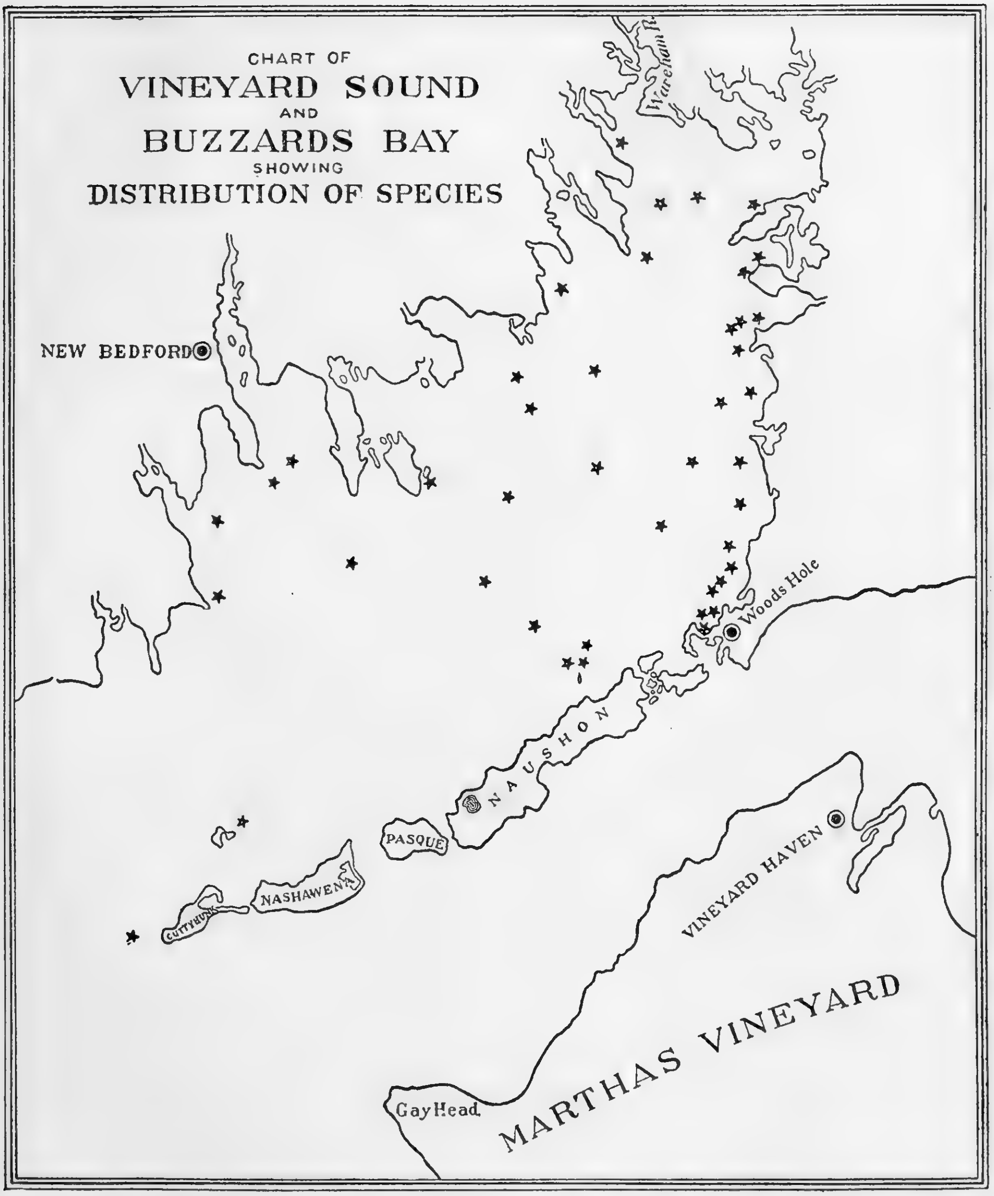

CHART 67.—Chætopterus pergamentaceus (tubes only).

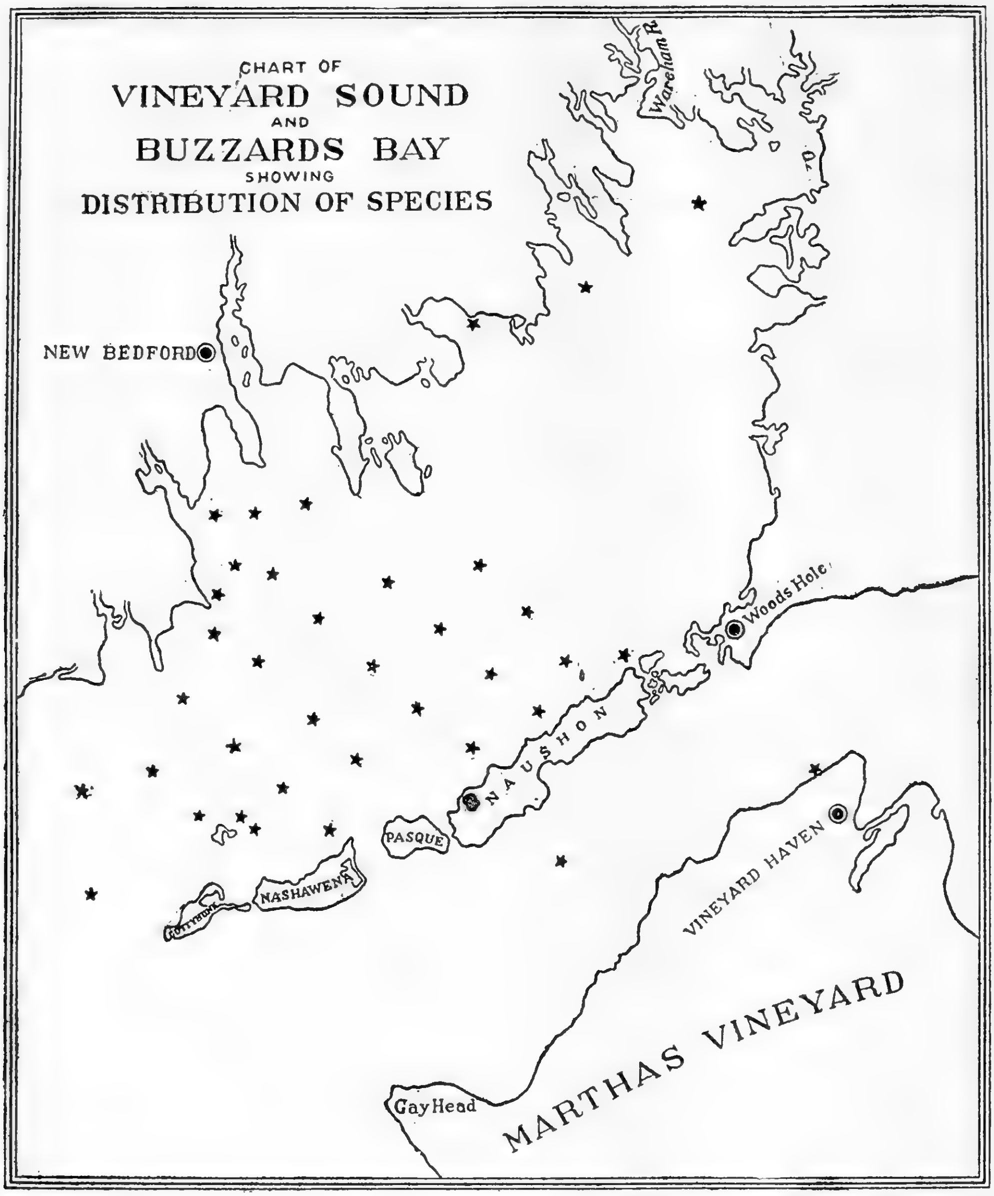

CHART 68.—Spiochætopterus oculatus.

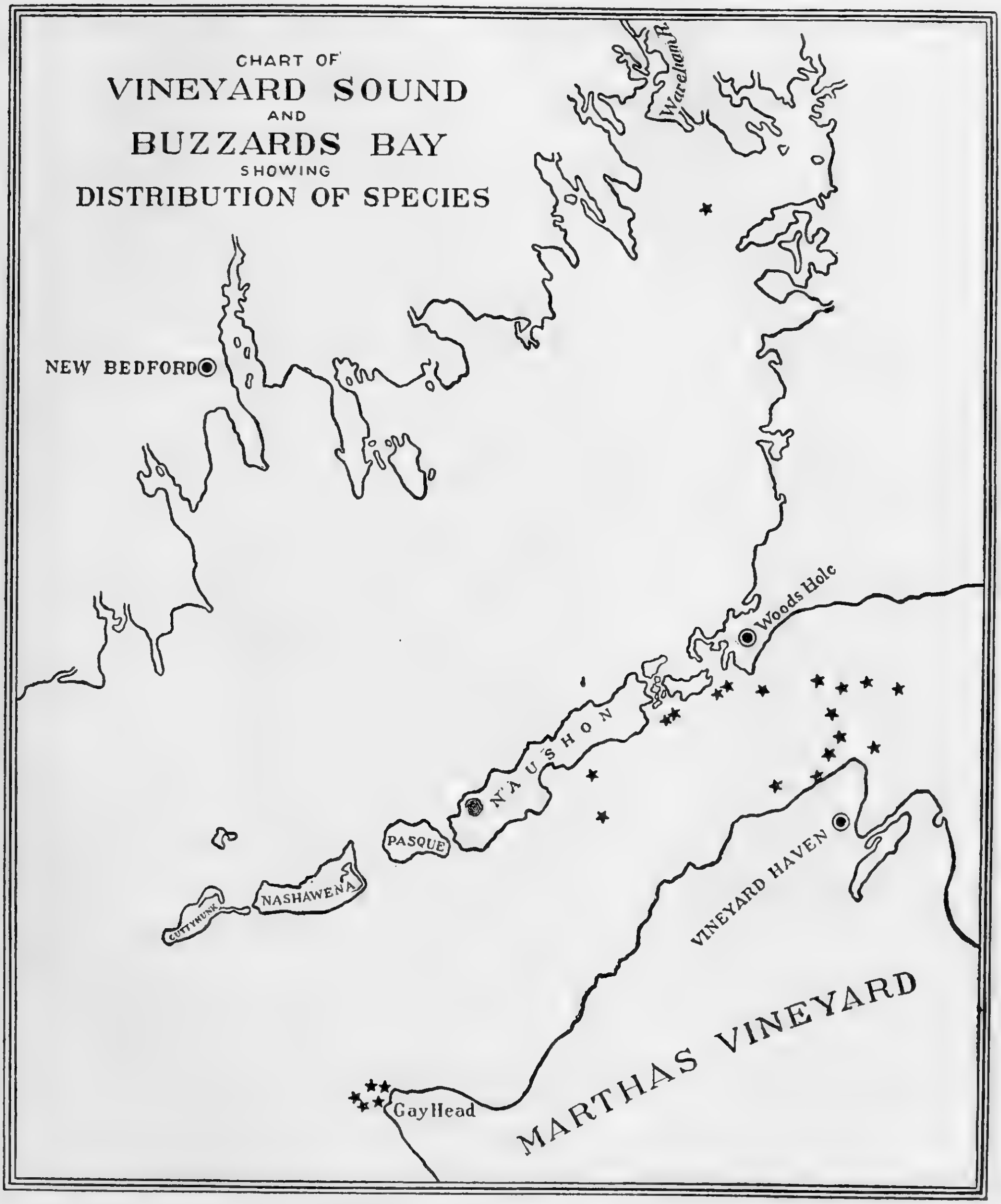

CHART 69.—Lepræa rubra.

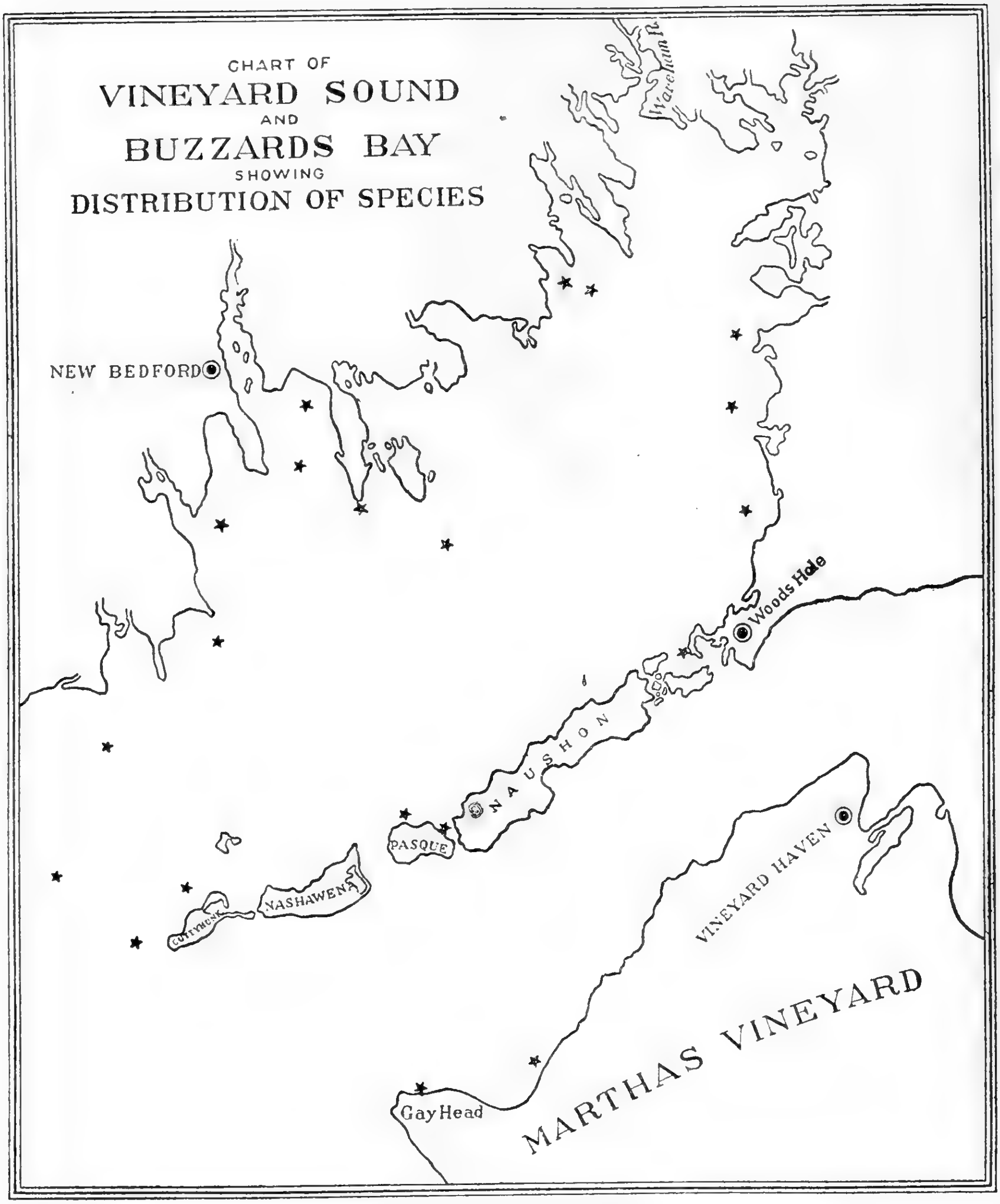

CHART 70.—Pista intermedia.

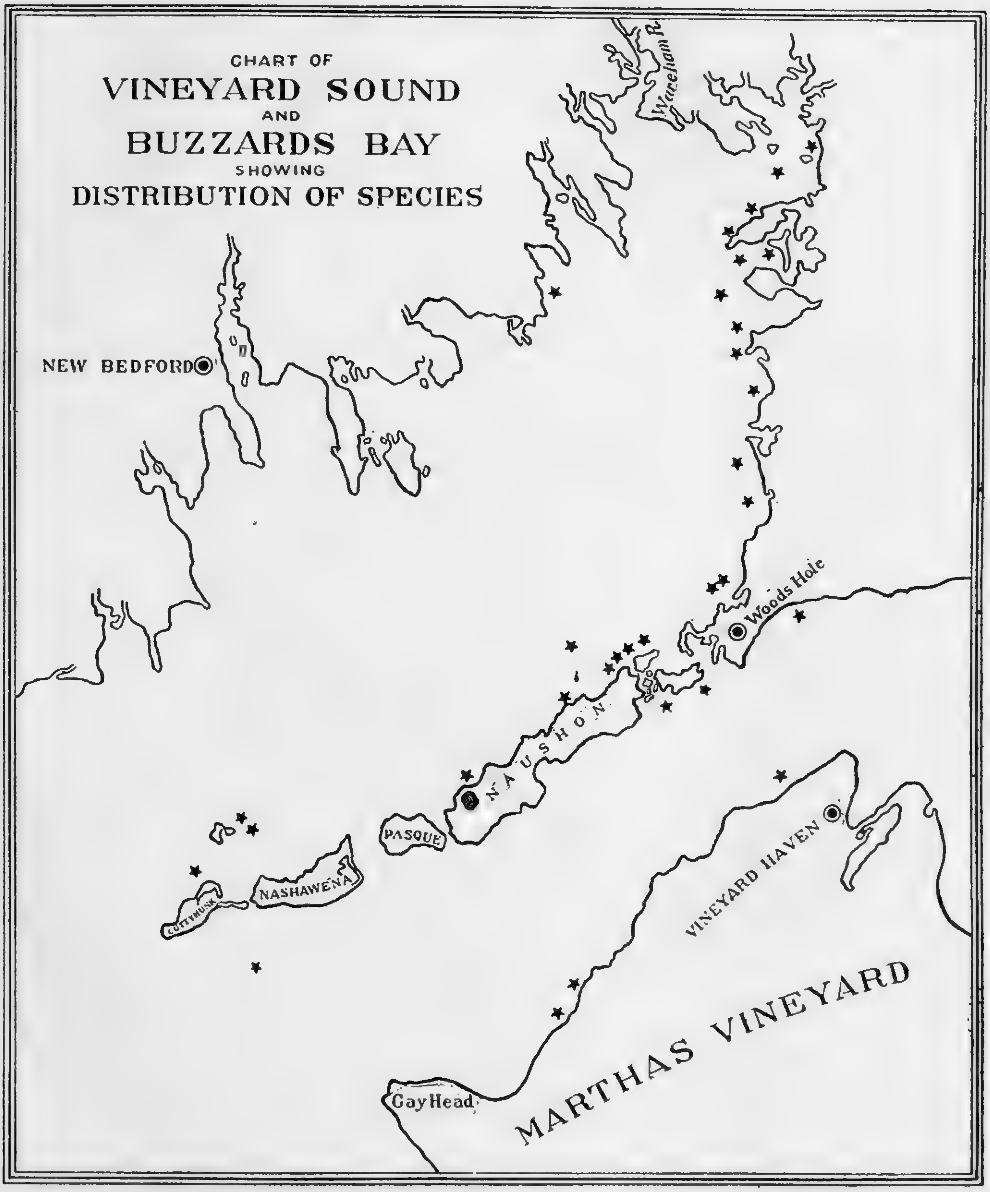

CHART 71.—Pista palmata.

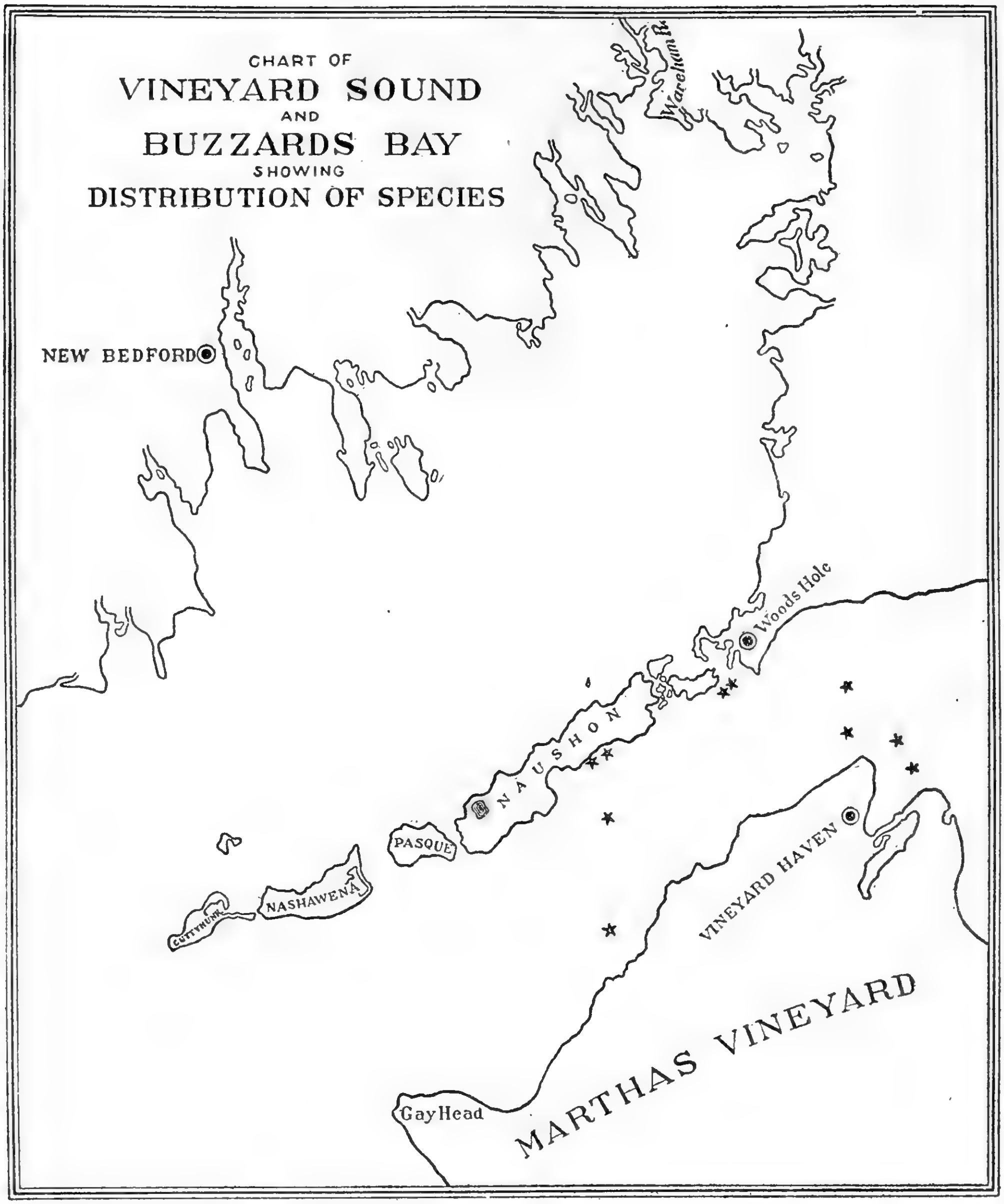

CHART 72.—Polycirrus eximeus.

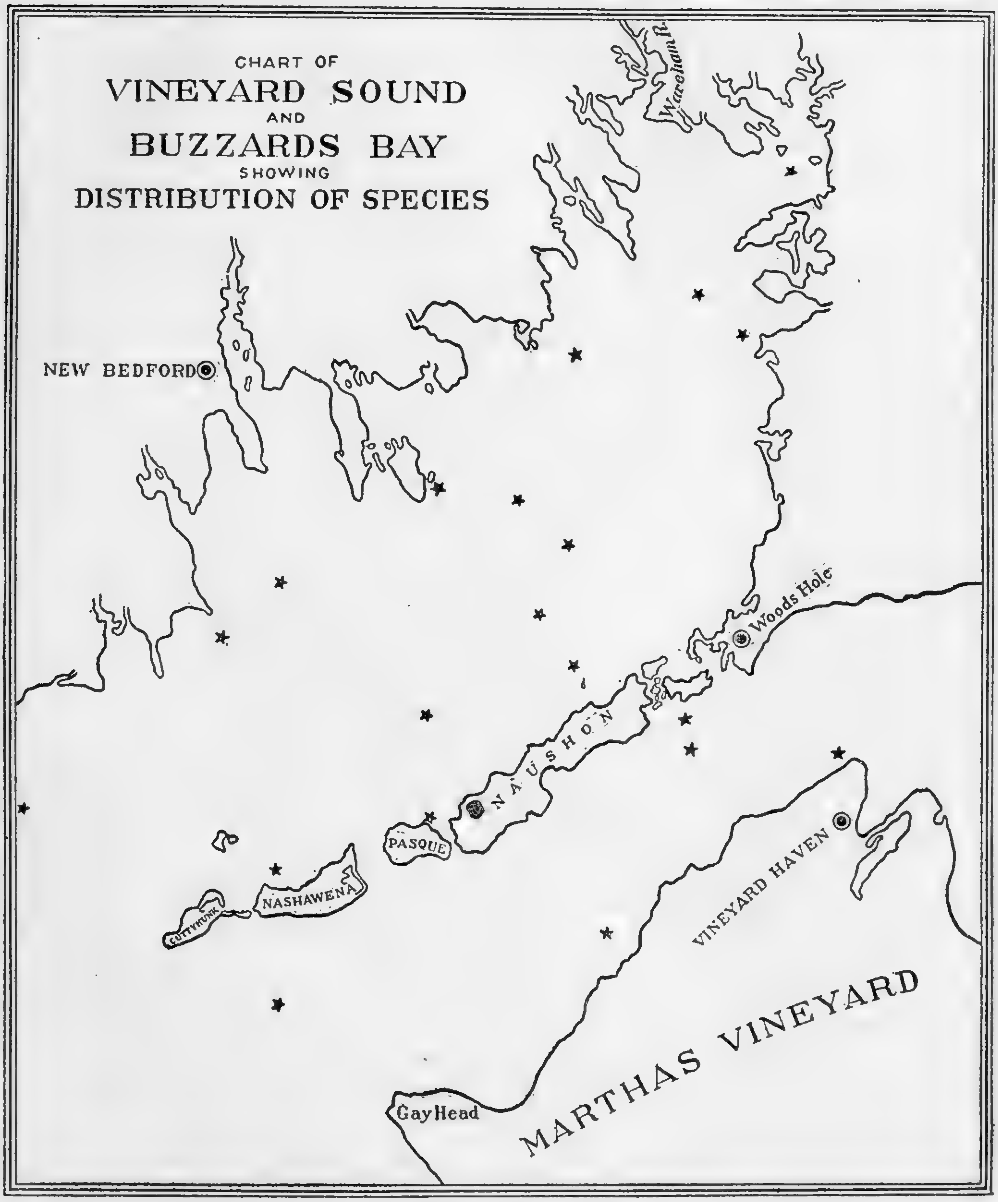

CHART 73.—Ampharete setosa.

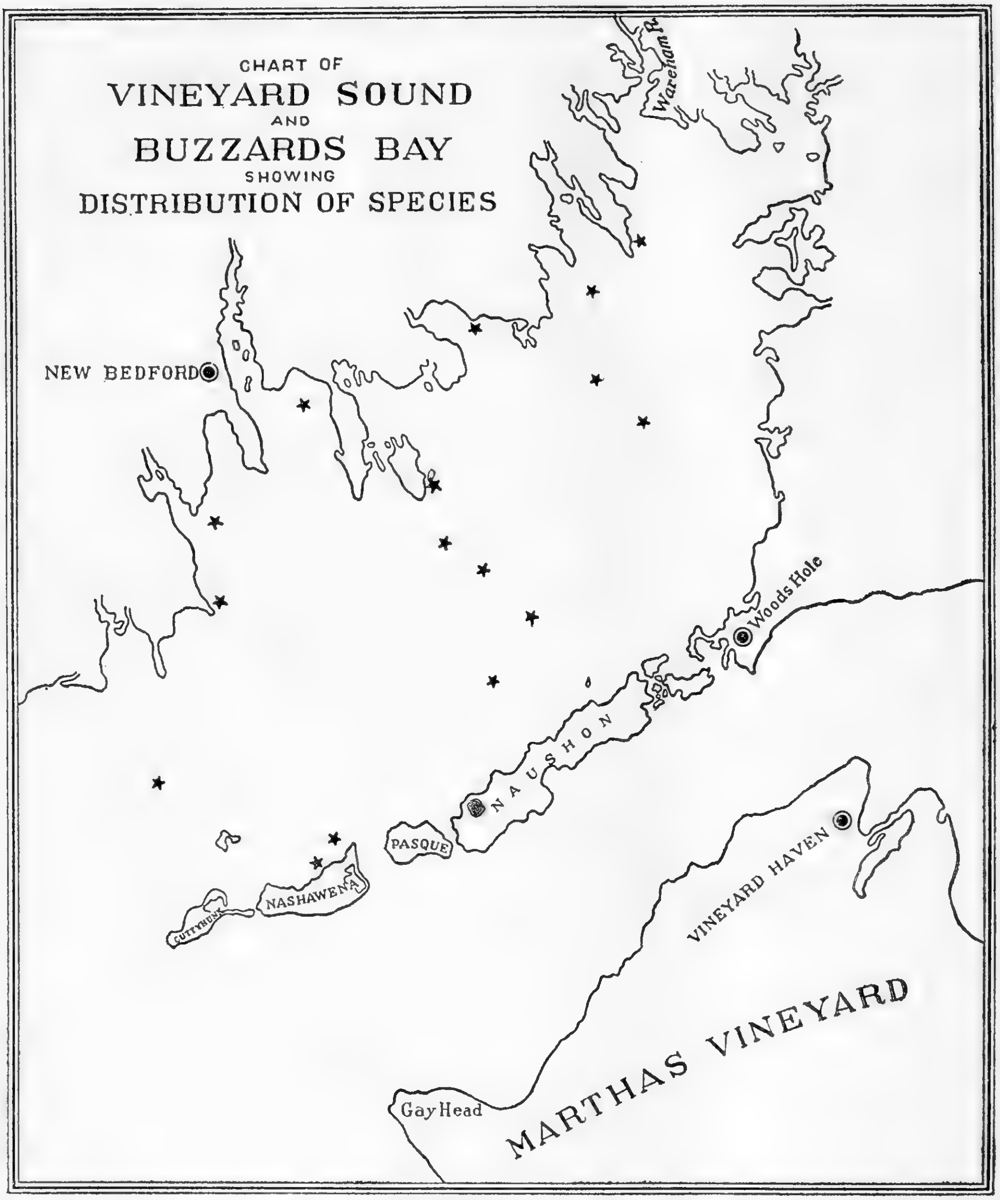

CHART 74.—Melinna maculata.

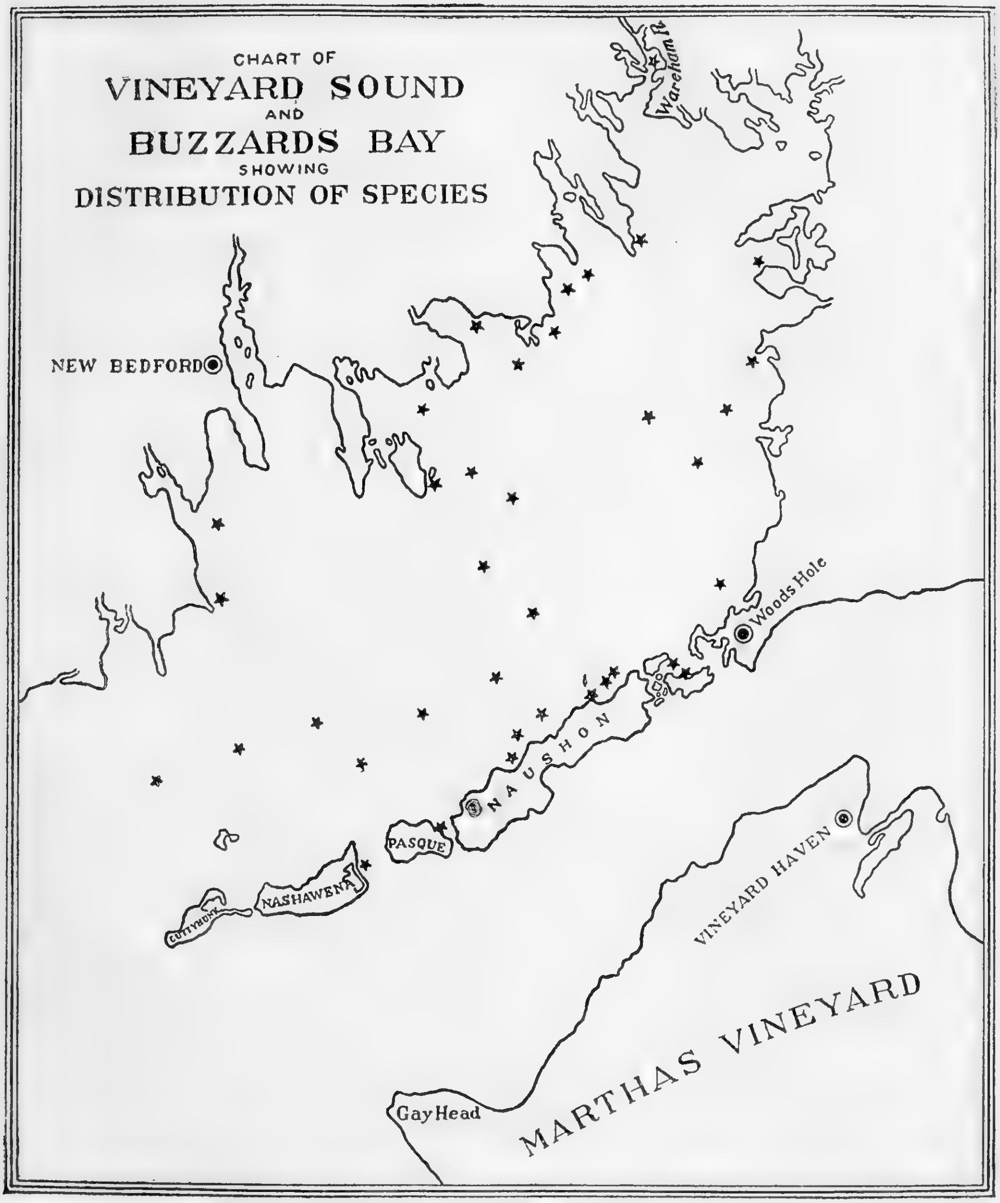

CHART 75.—Cistenides gouldii.

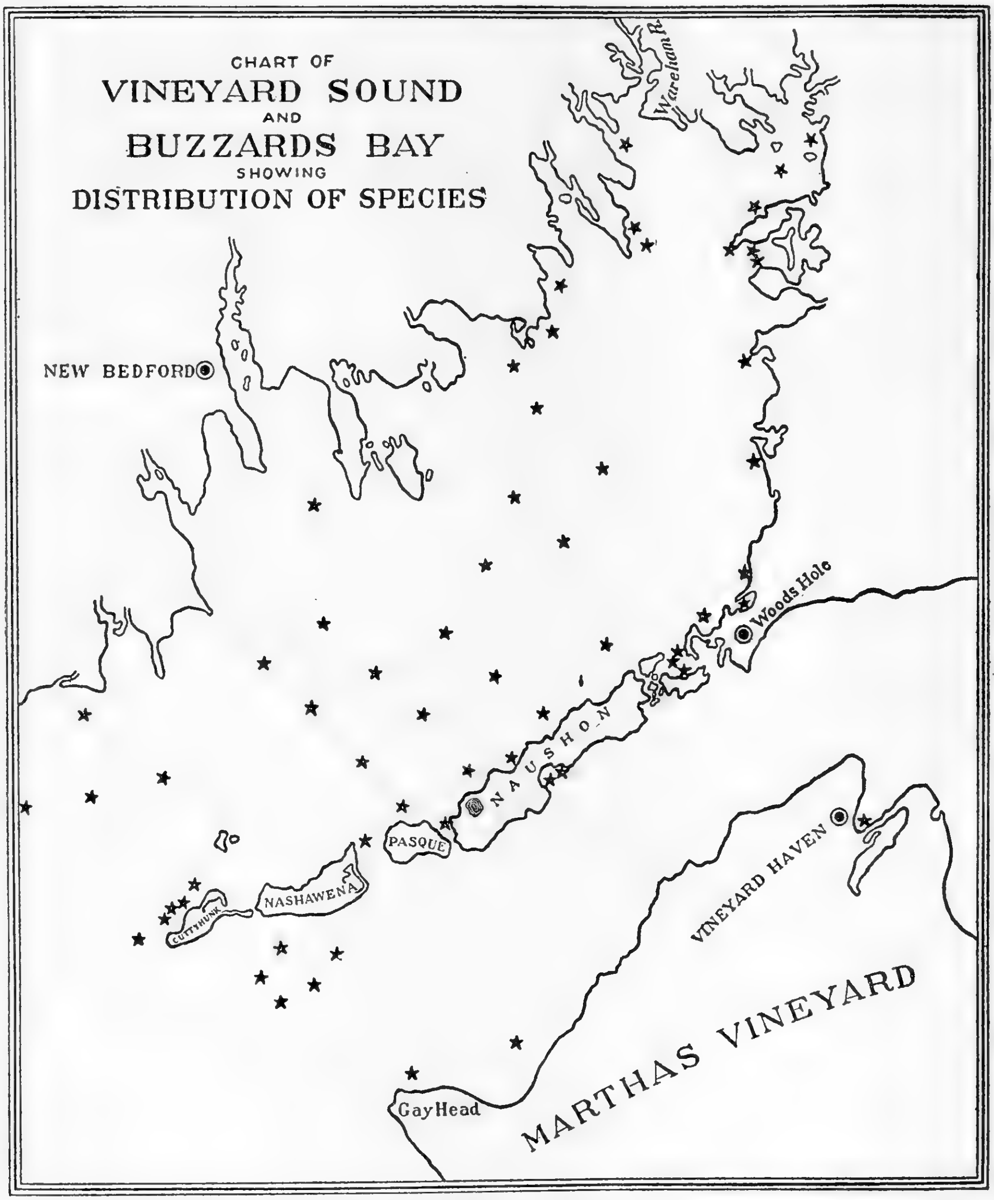

CHART 76.—Clymenella torquata.

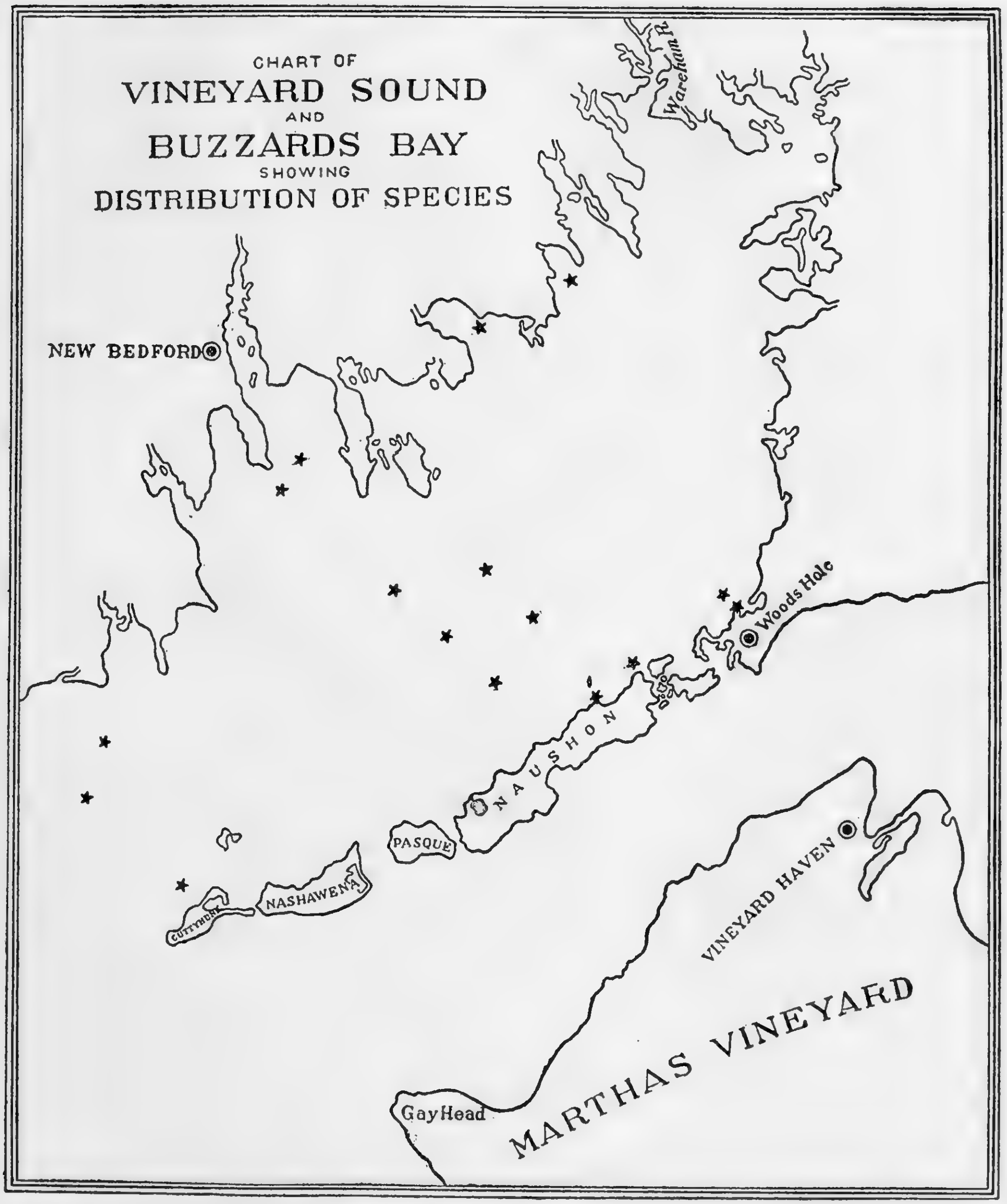

CHART 77.—Maldane elongata.

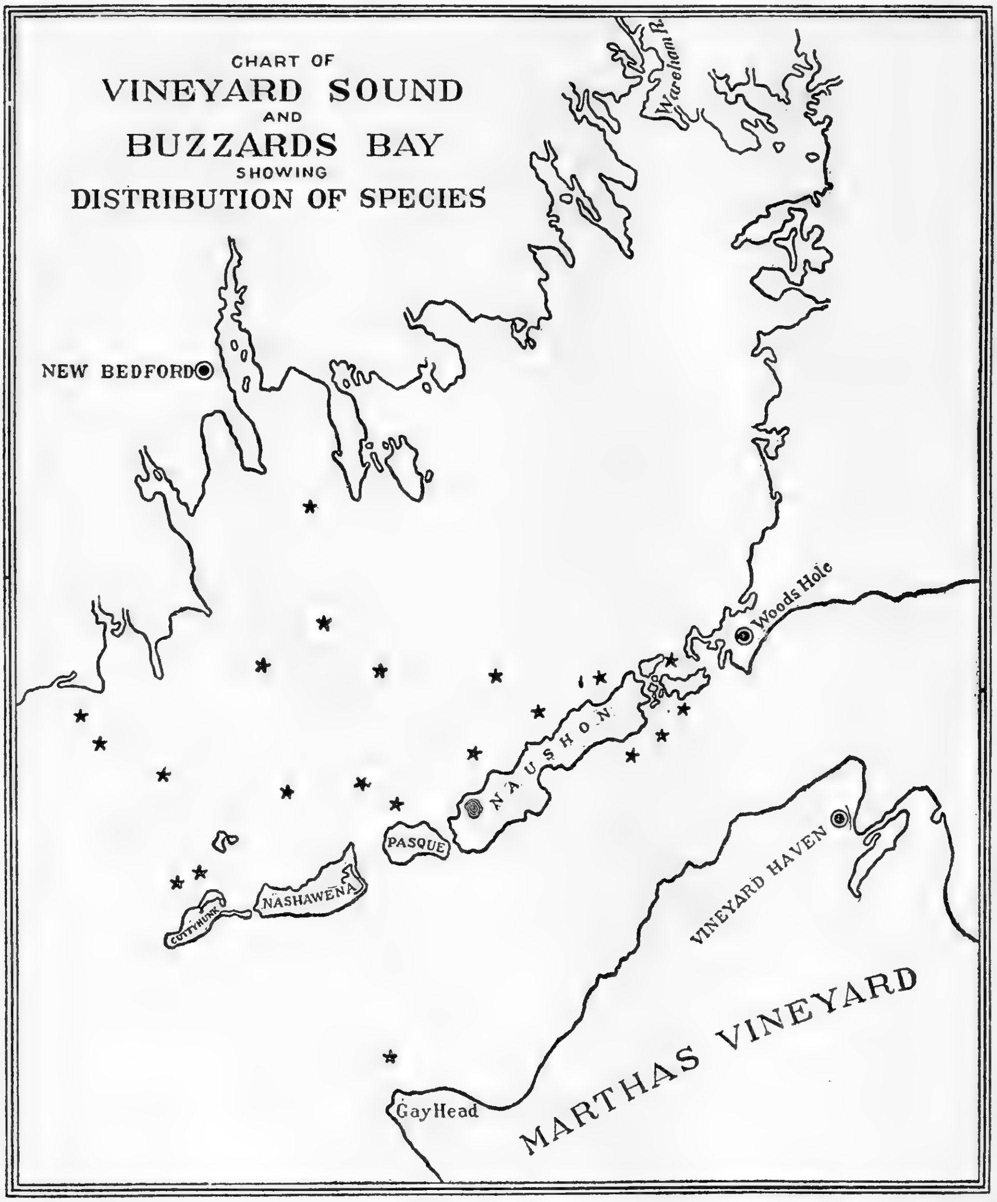

CHART 78.—Trophonia affinis.

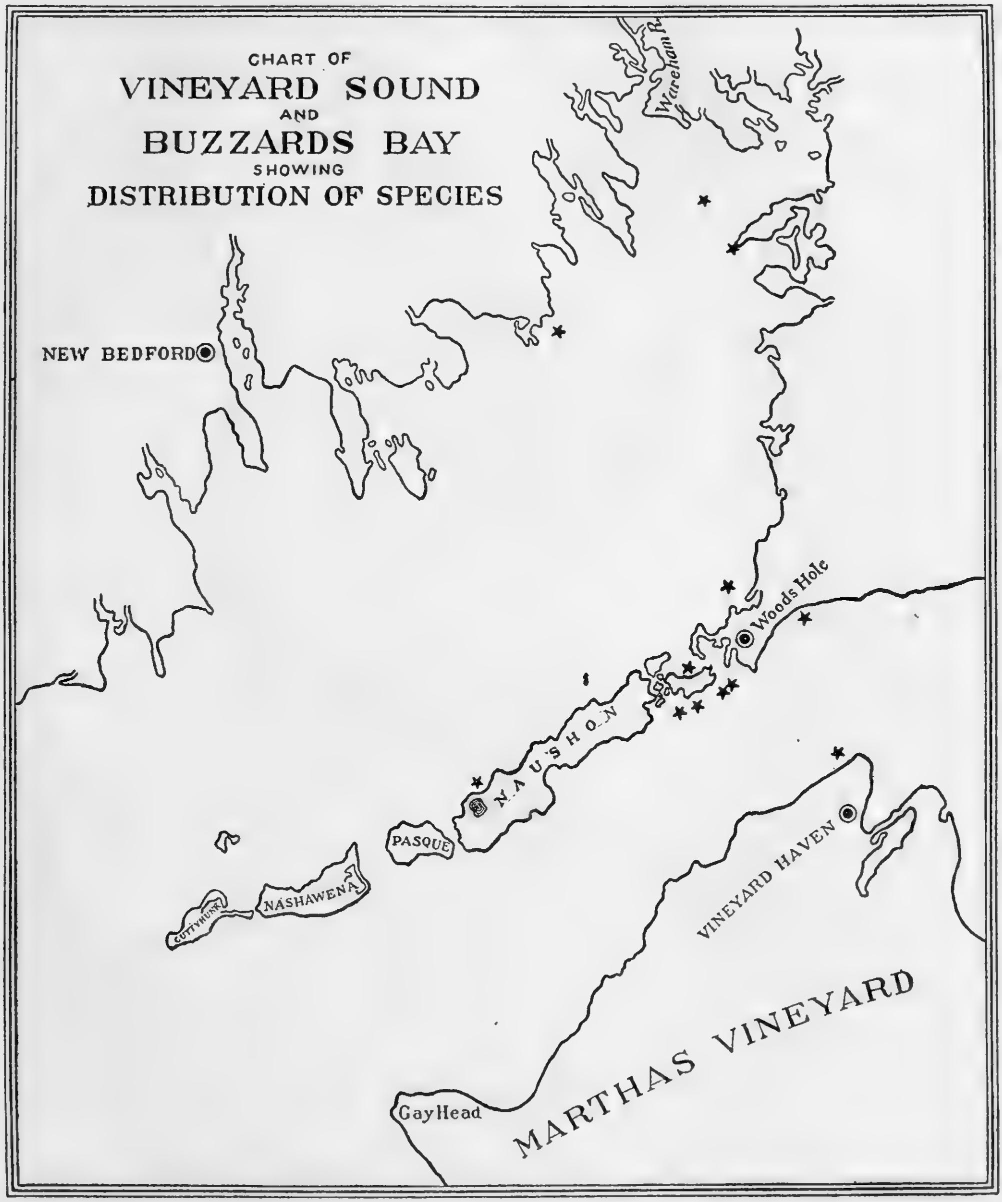

CHART 79.—Parasabella microphthalmia.

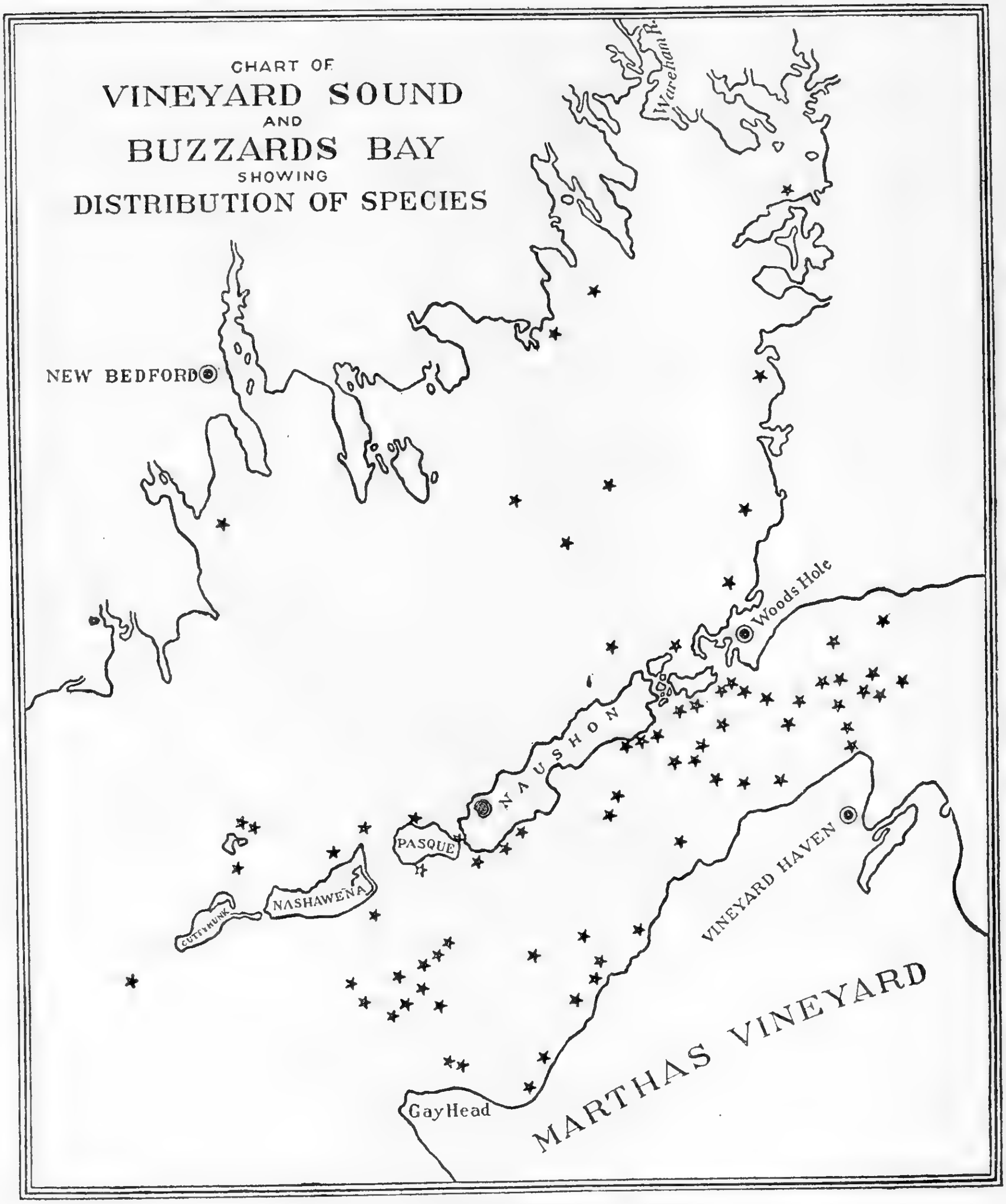

CHART 80.—Pseudopotamilla oculifera.

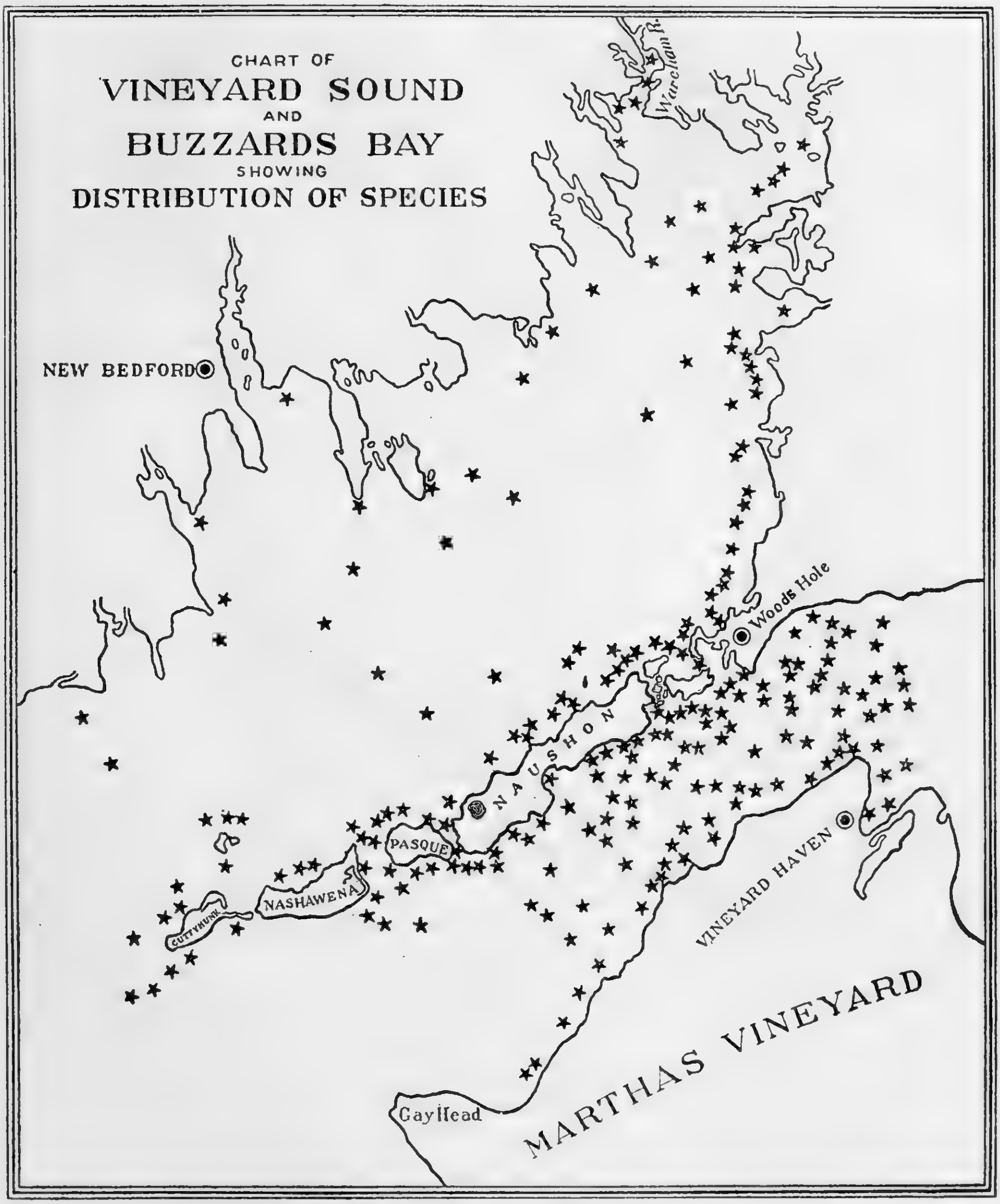

CHART 81.—Hydroides dianthus.

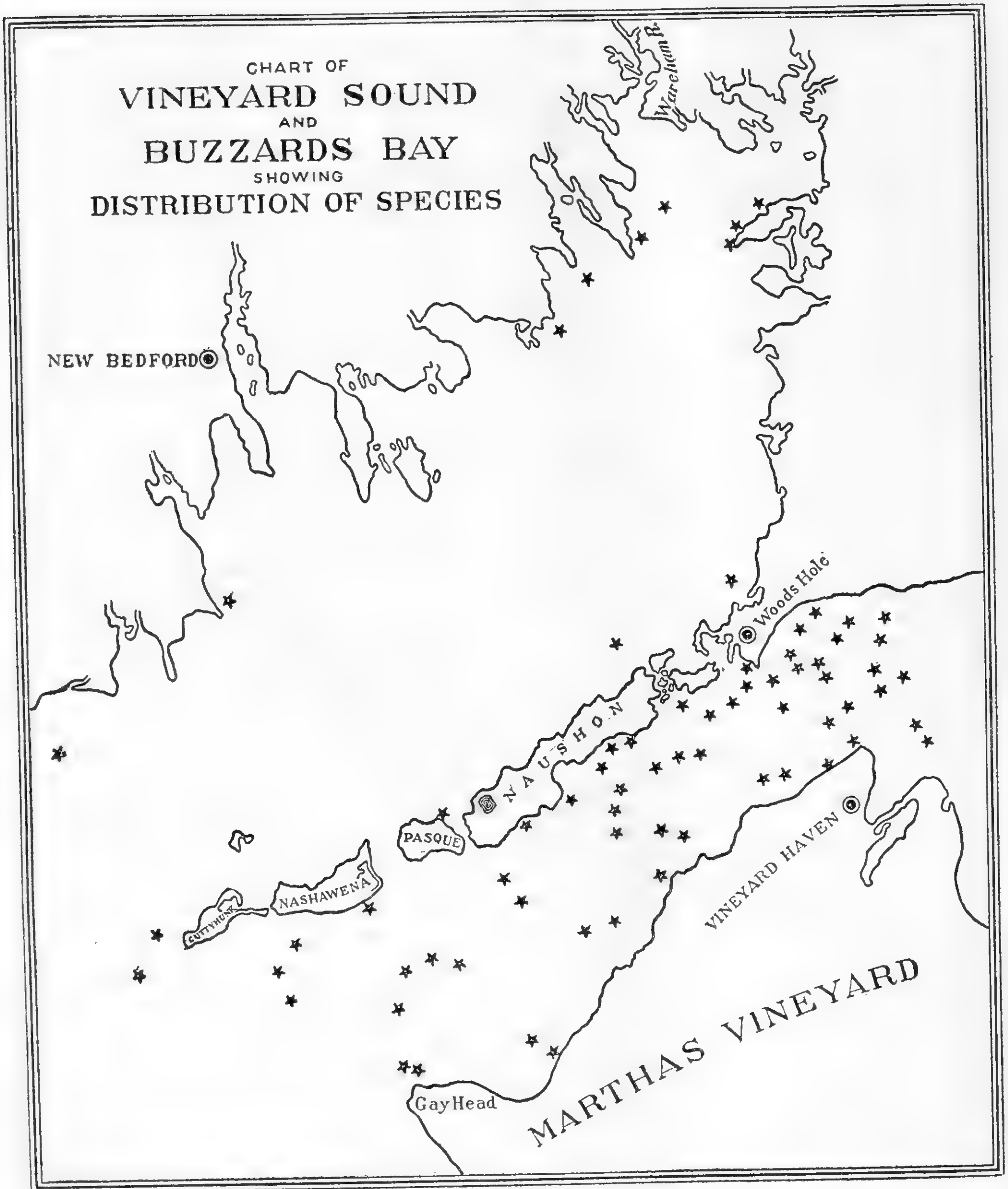

CHART 82.—Sabellaria vulgaris.

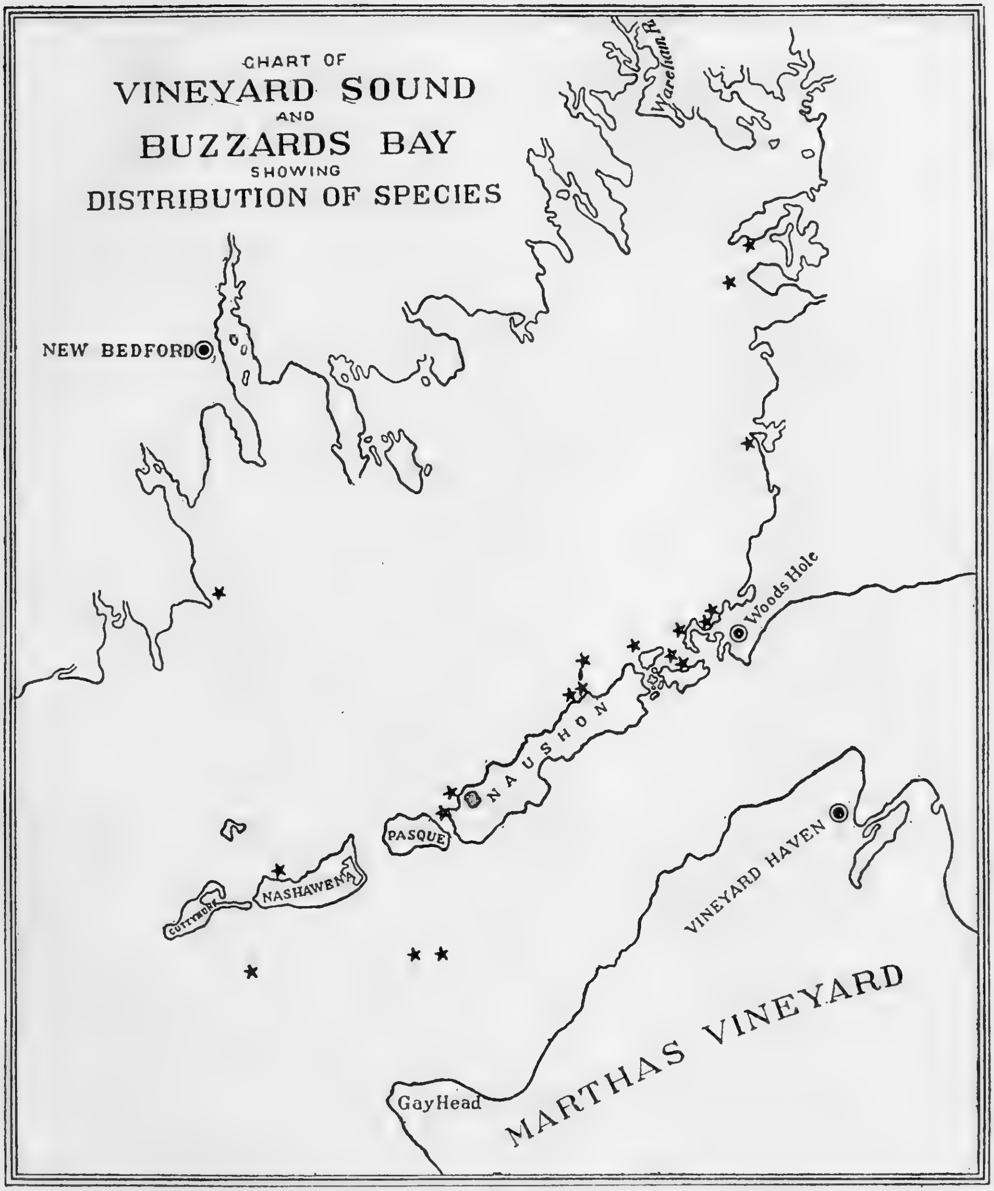

CHART 83.—Phascolion strombi.

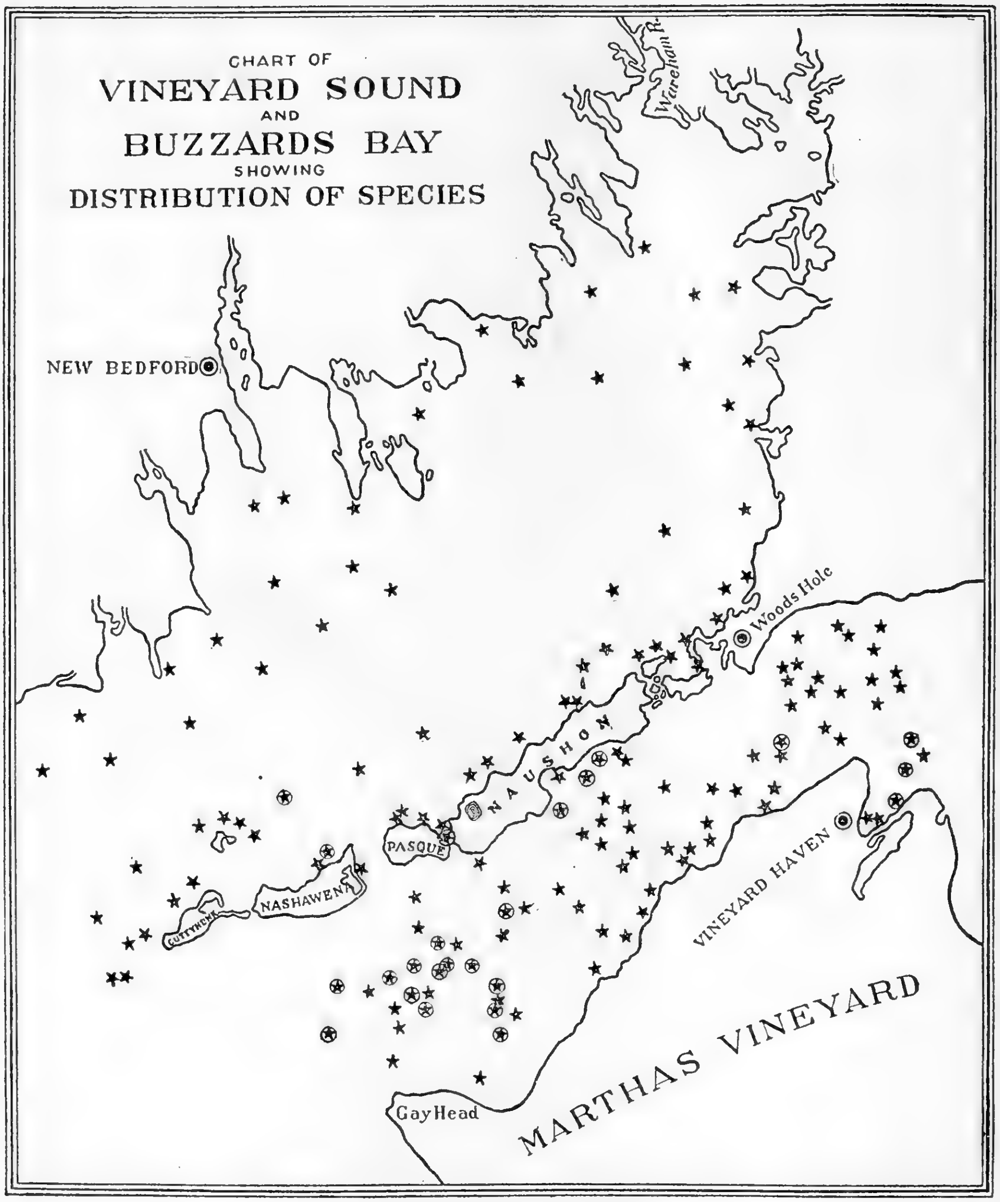

CHART 84.—Balanus eburneus.

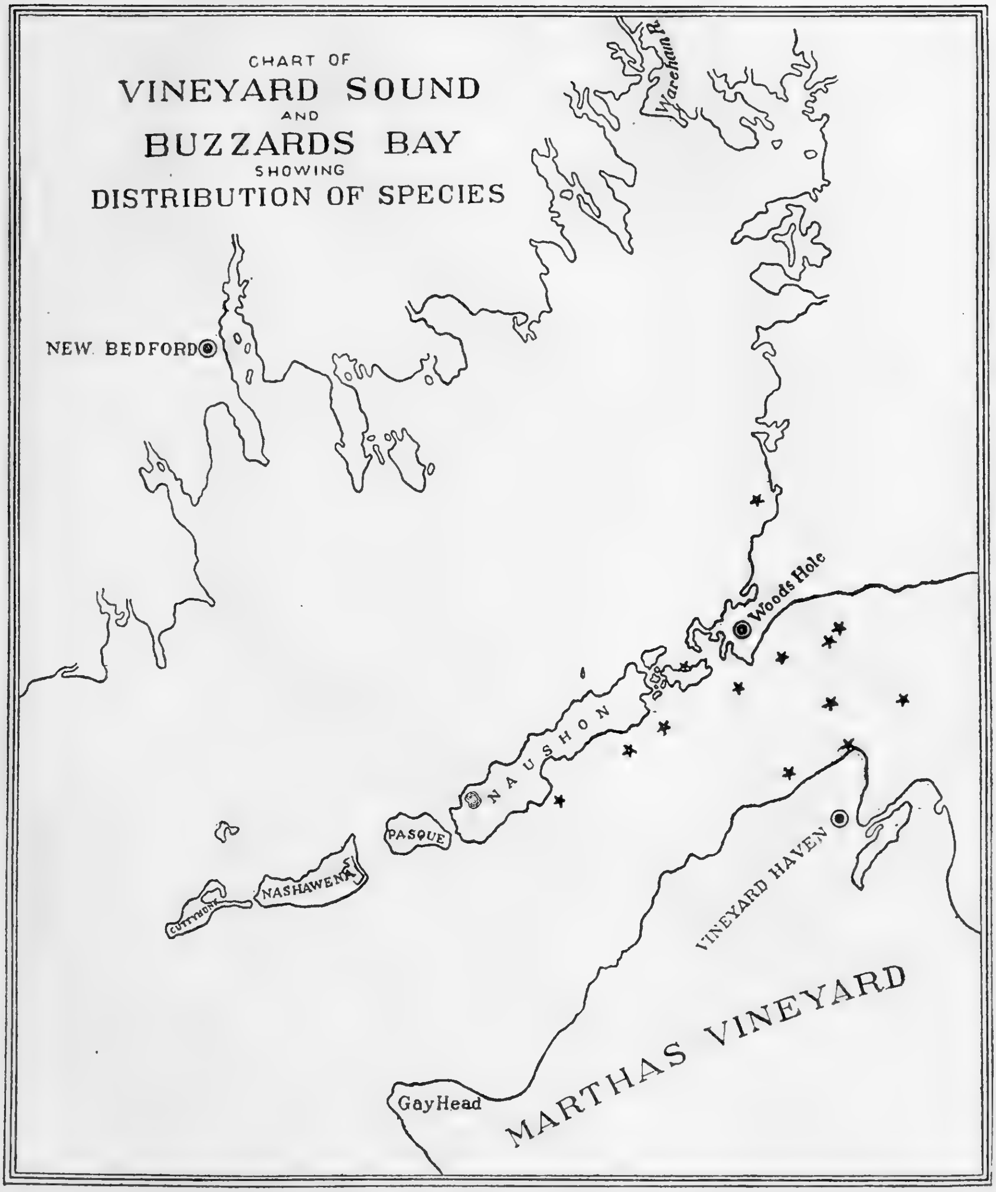

CHART 85.—Lysianopsis alba.

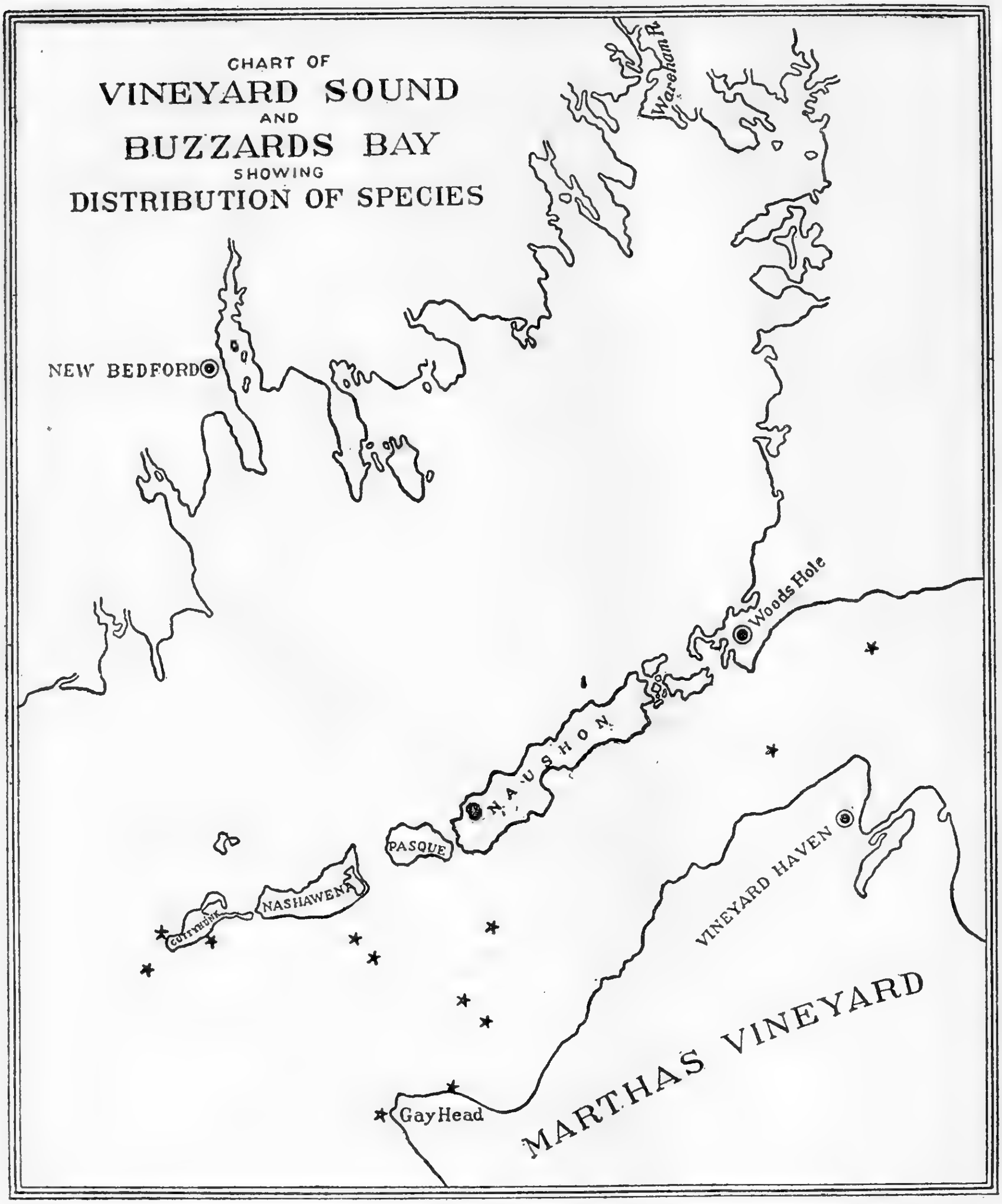

CHART 86.—Haustorius arenarius.

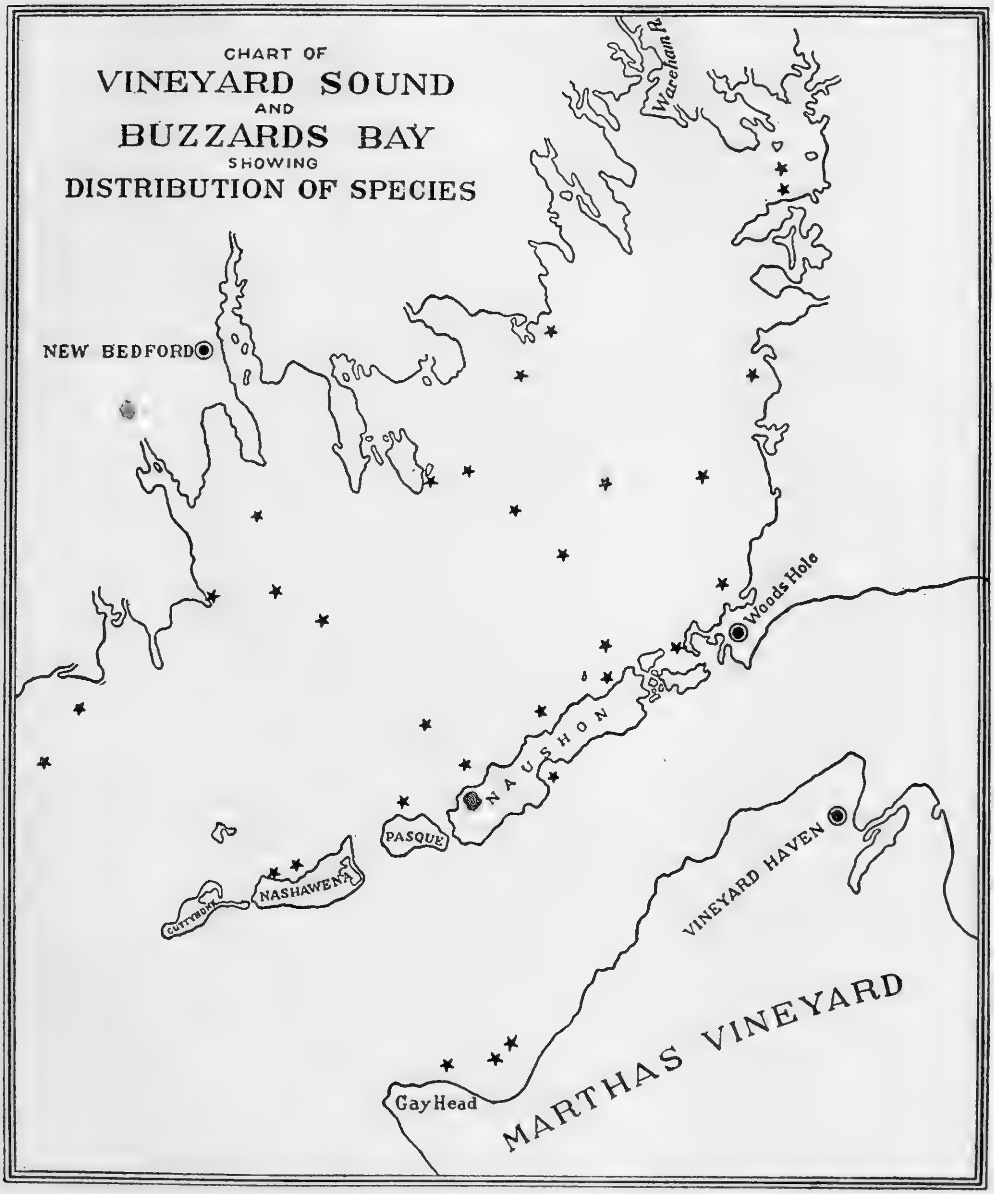

CHART 87.—Ampelisca macrocephala.

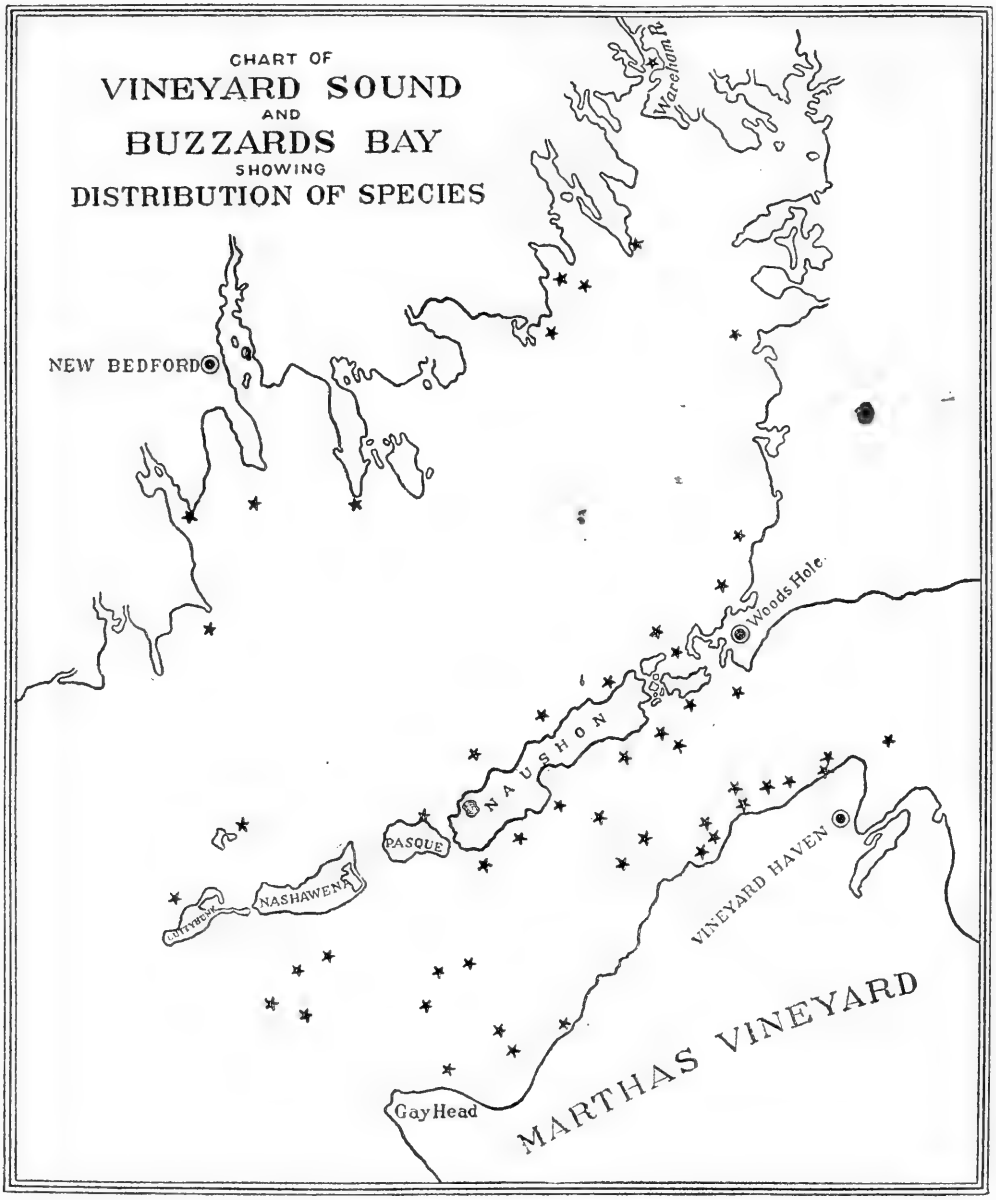

CHART 88.—Ampelisca spinipes.

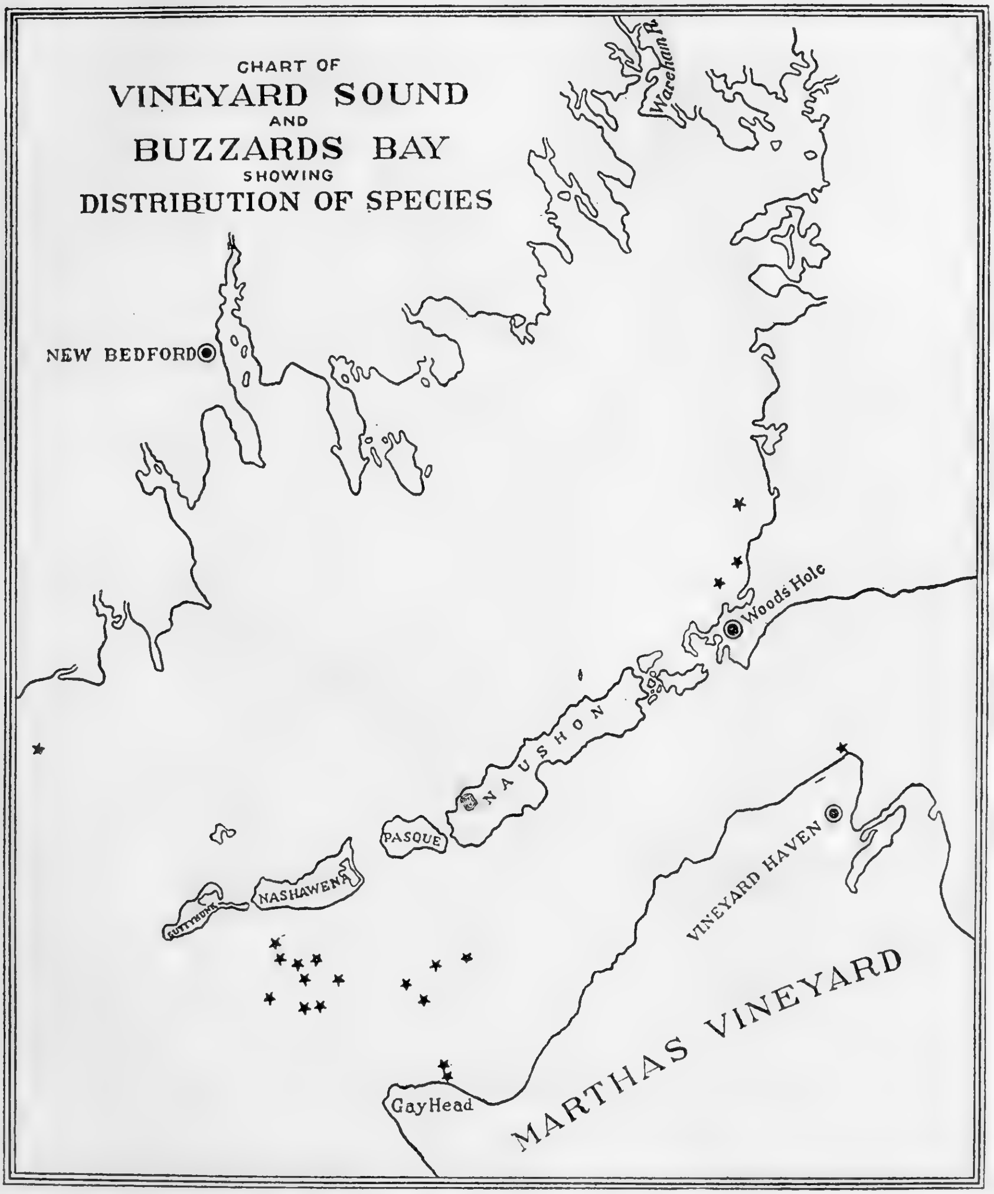

CHART 89.—Byblis serrata.

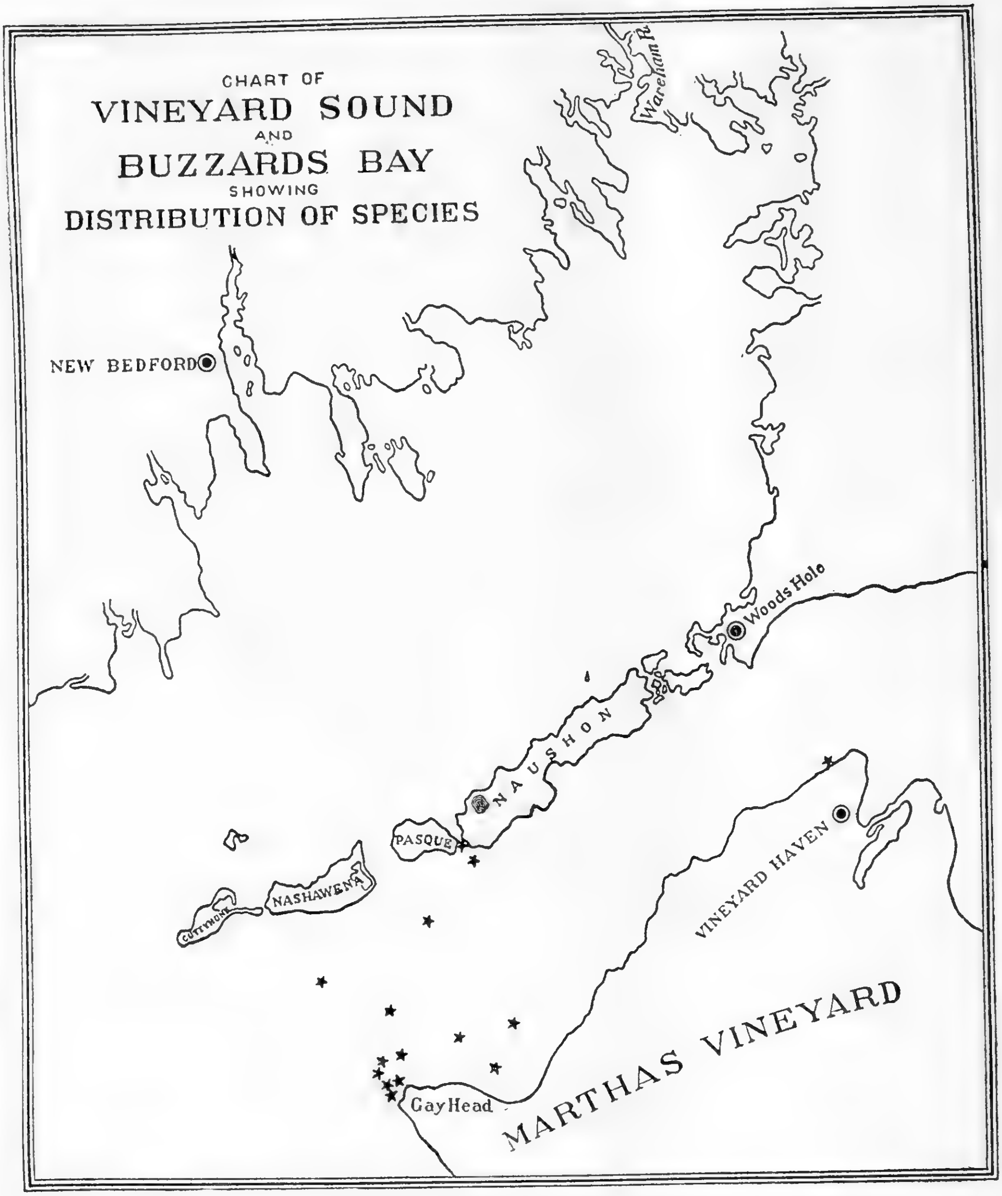

CHART 90.—Calliopius læviusculus.

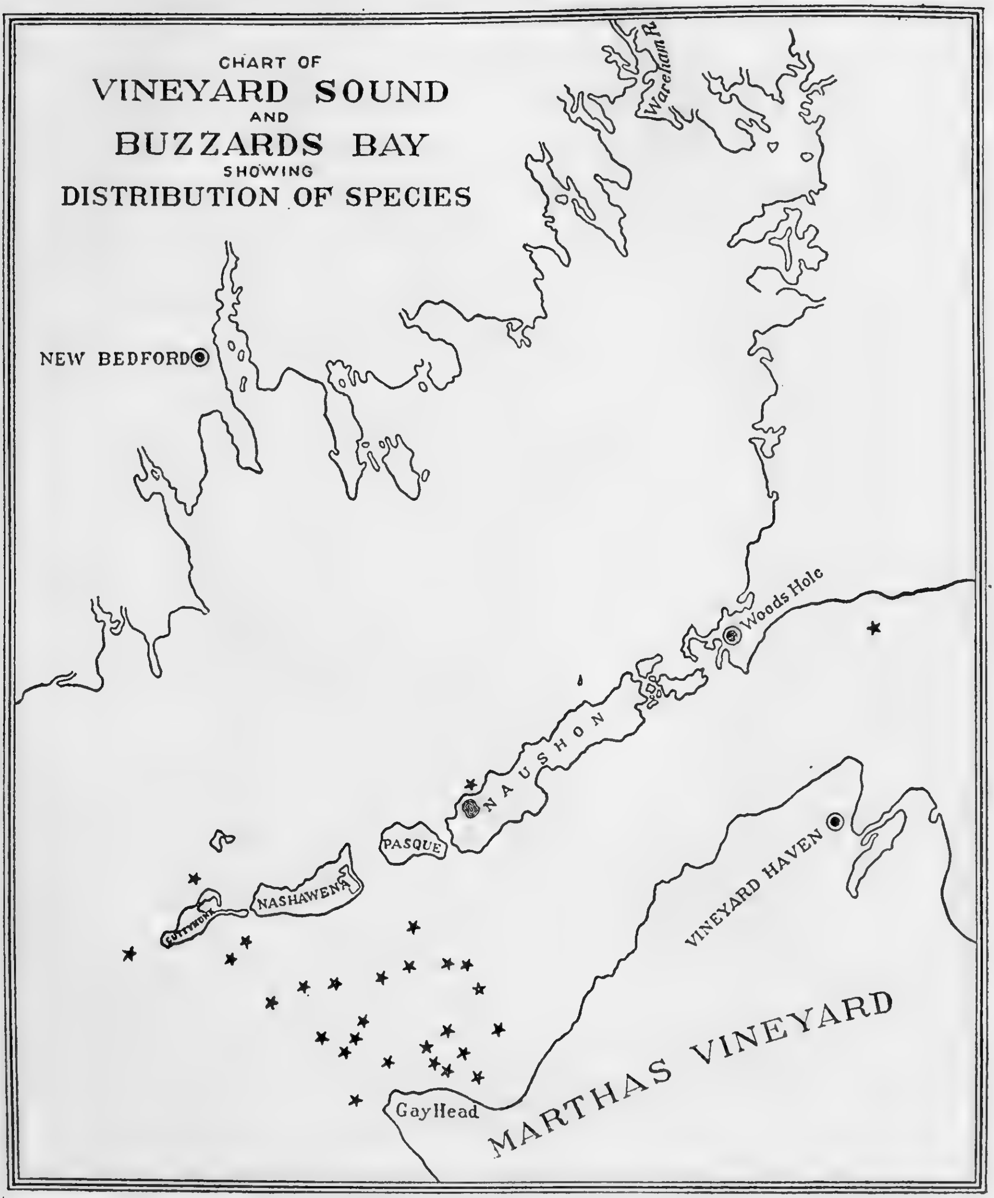

CHART 91.—Pontogenia inermis.

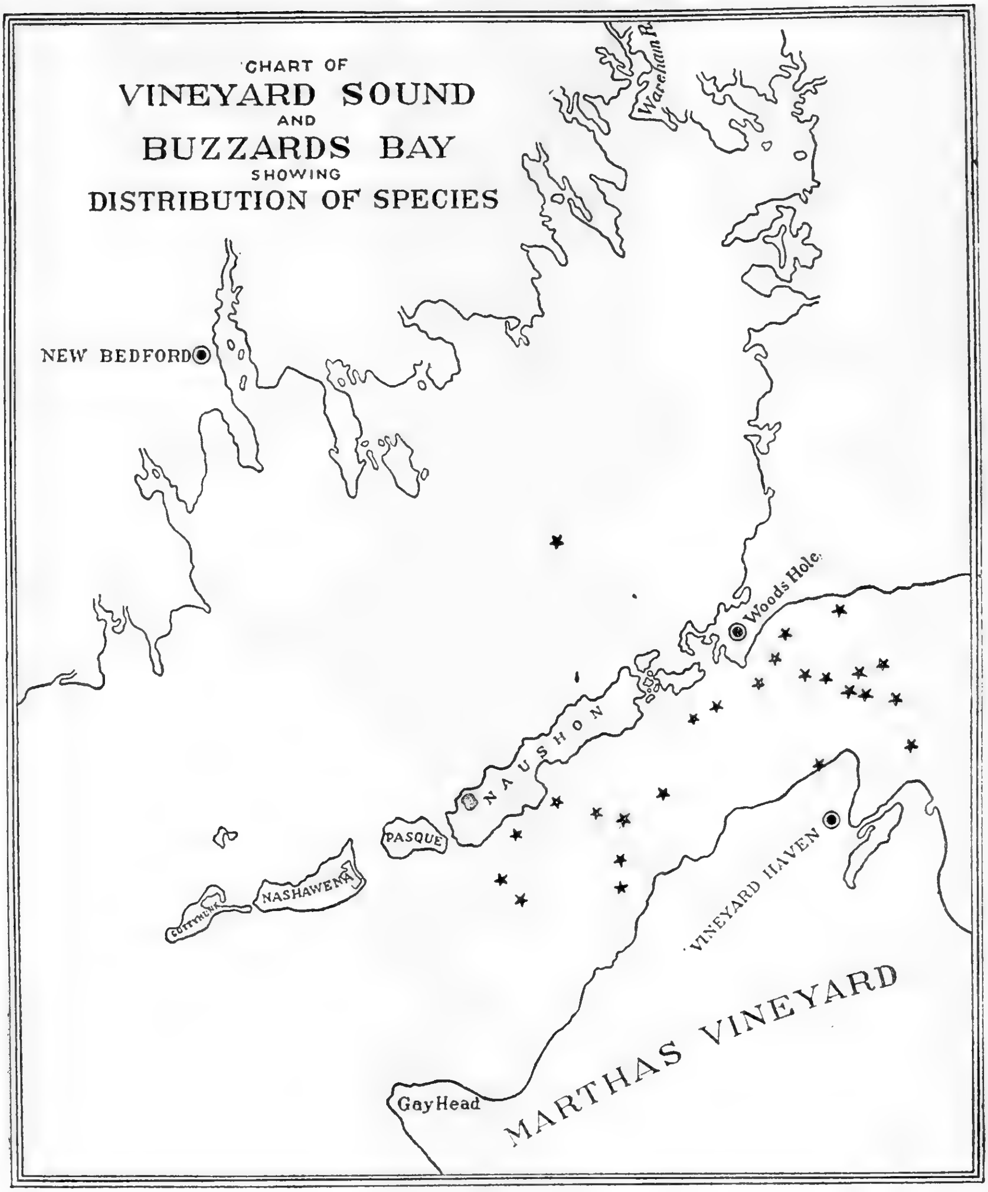

CHART 92.—Batea secunda.

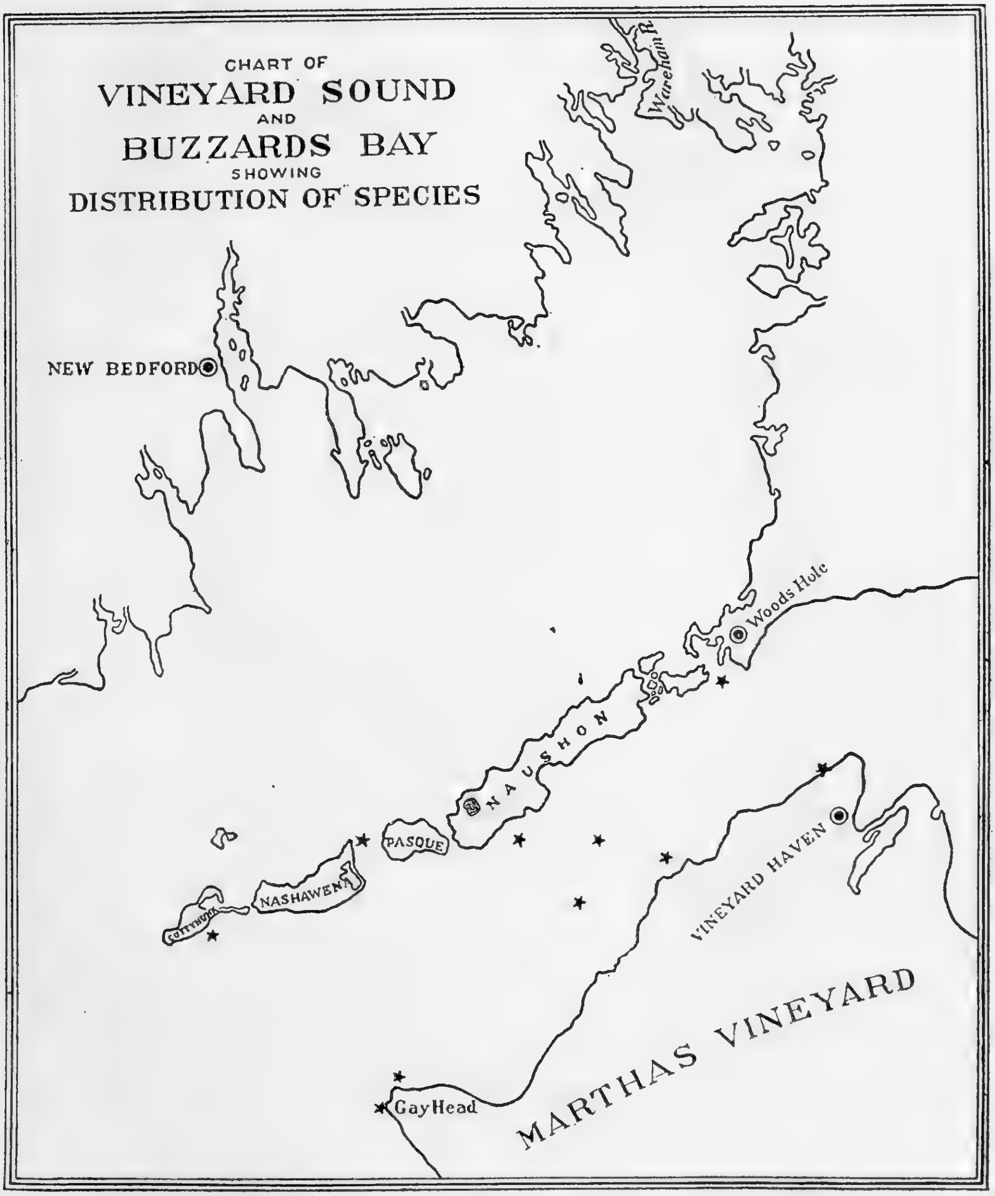

CHART 93.—Gammarus annulatus.

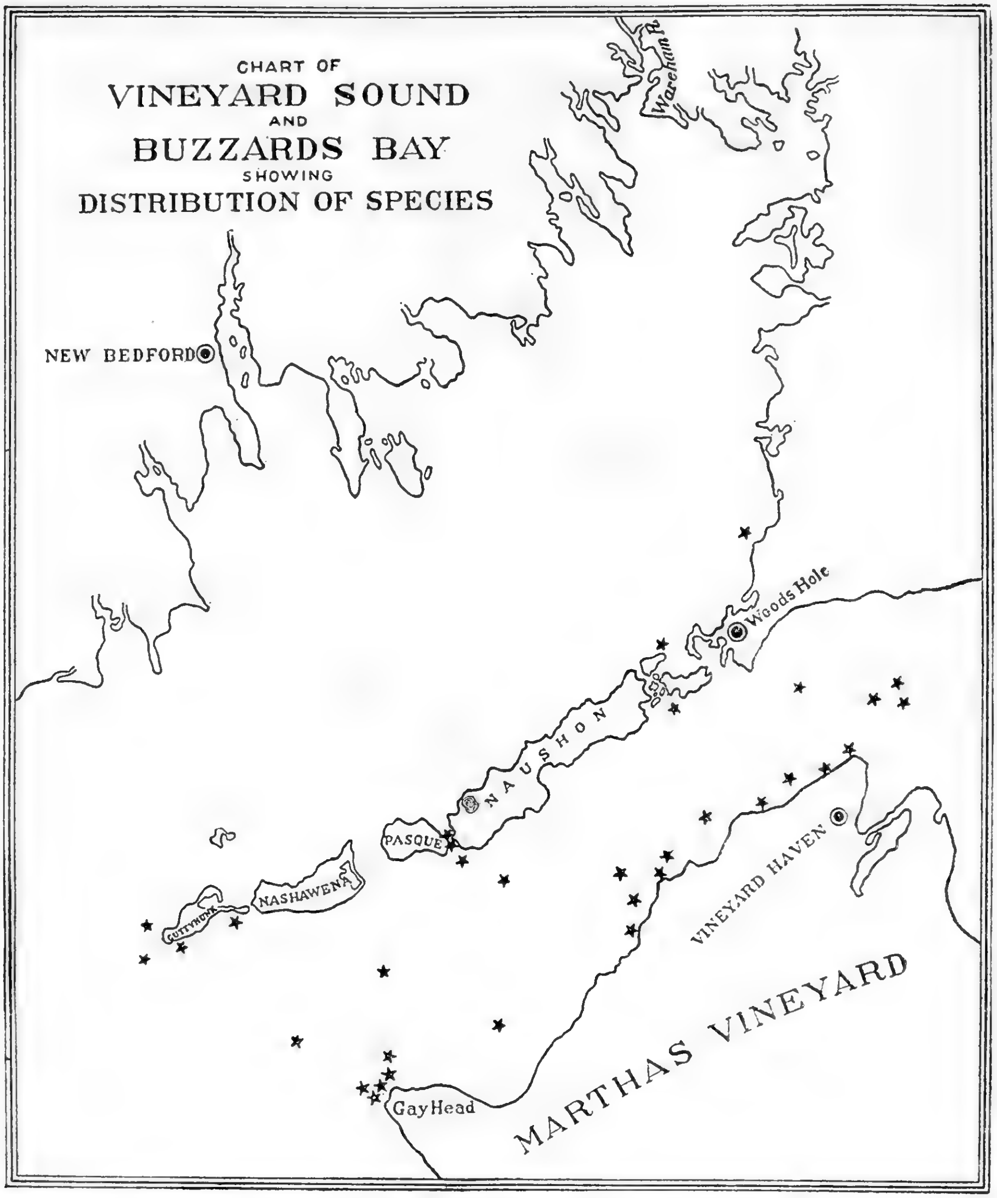

CHART 94.—Elasmopus lævis.

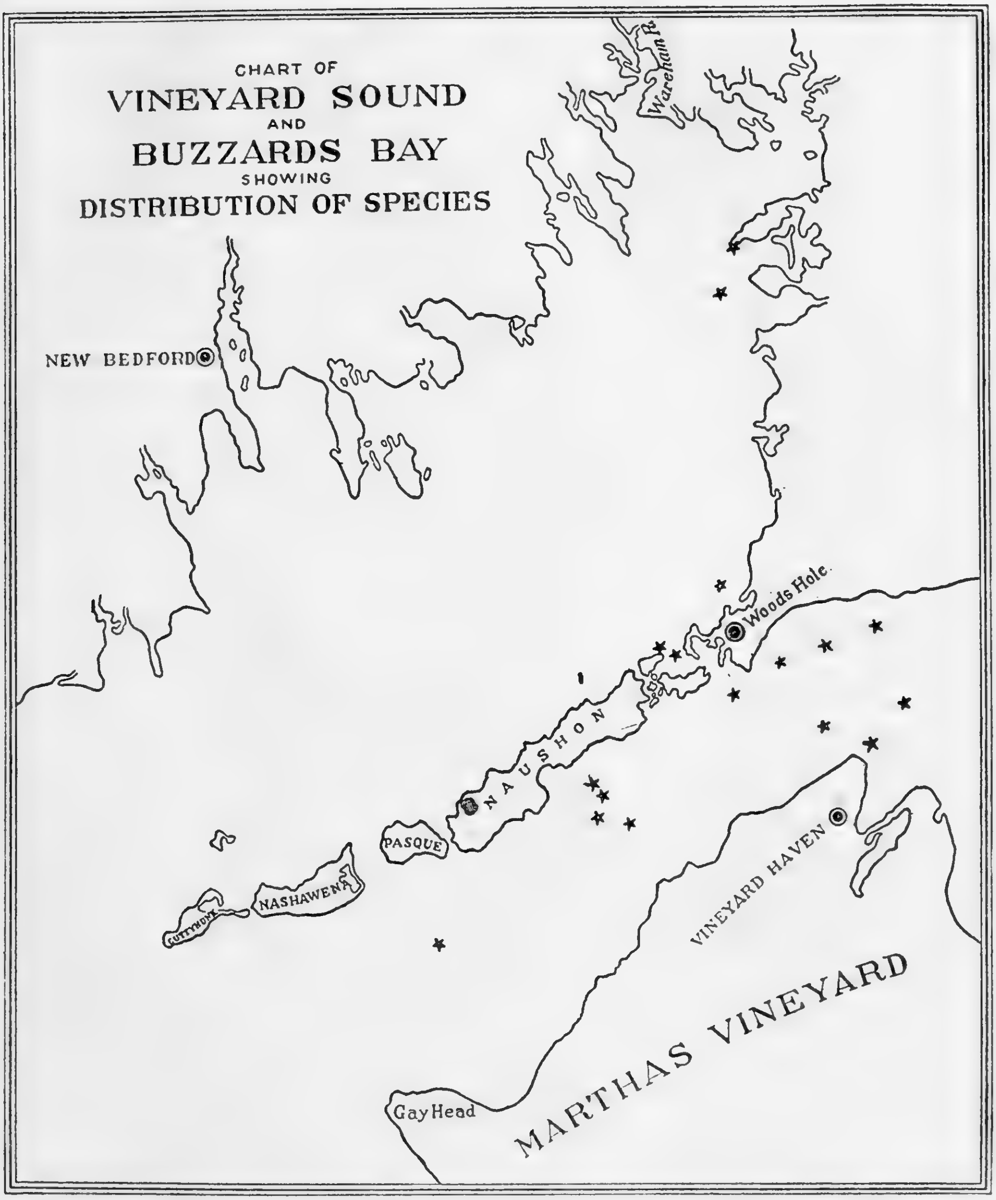

CHART 95.—Antonoë smithi.

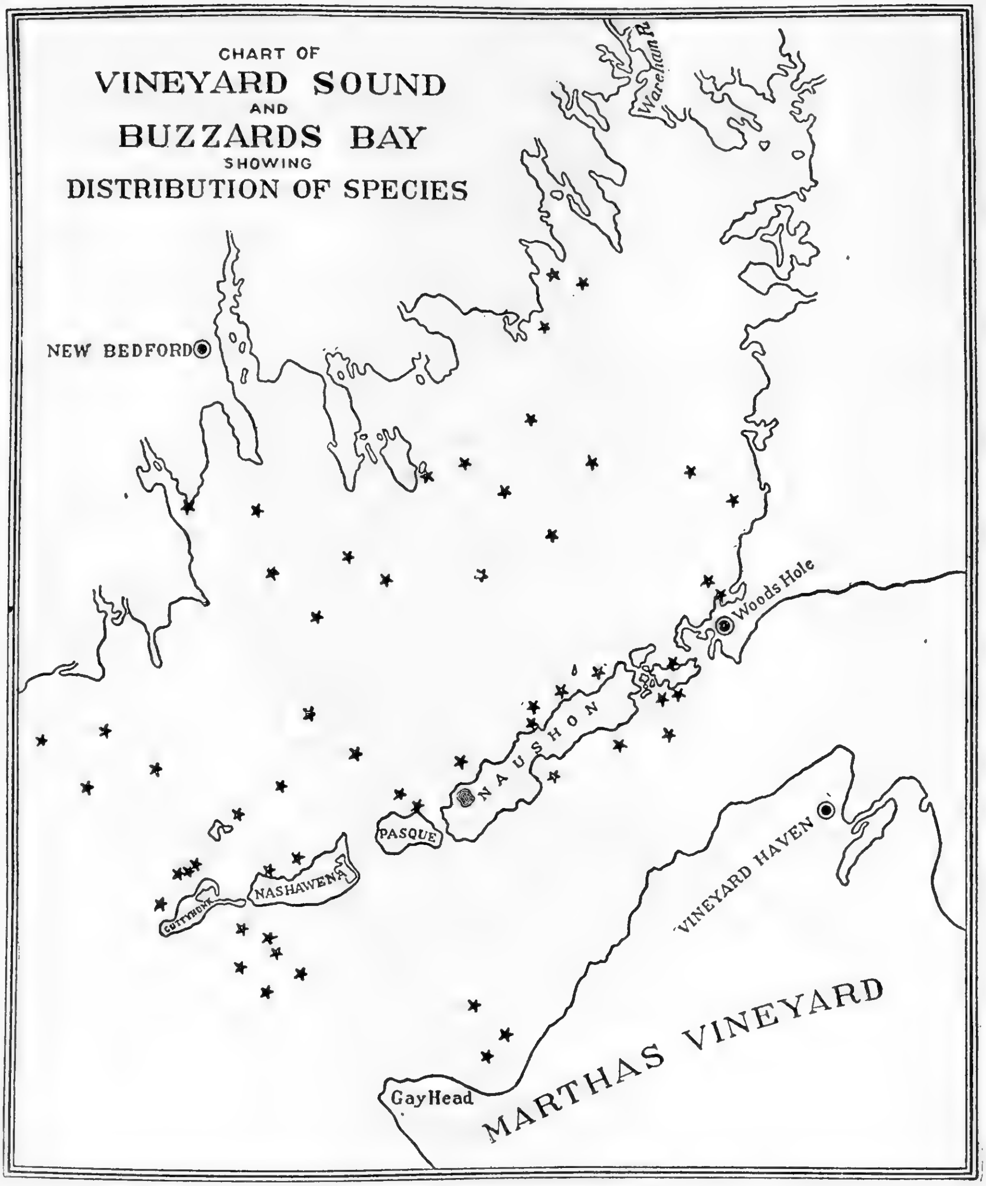

CHART 96.—Ptilocheirus pinguis.

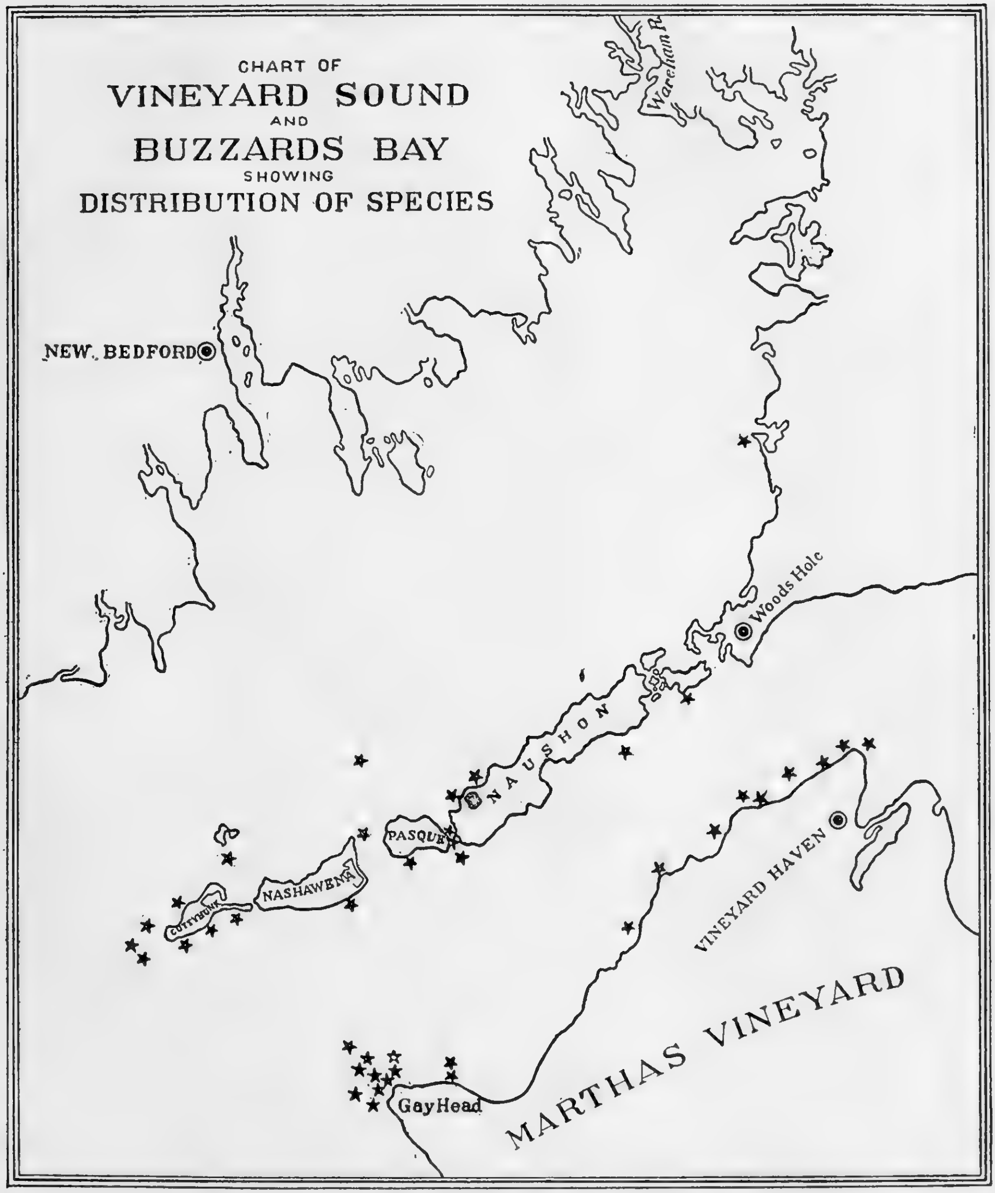

CHART 97.—Amphithoë rubricata.

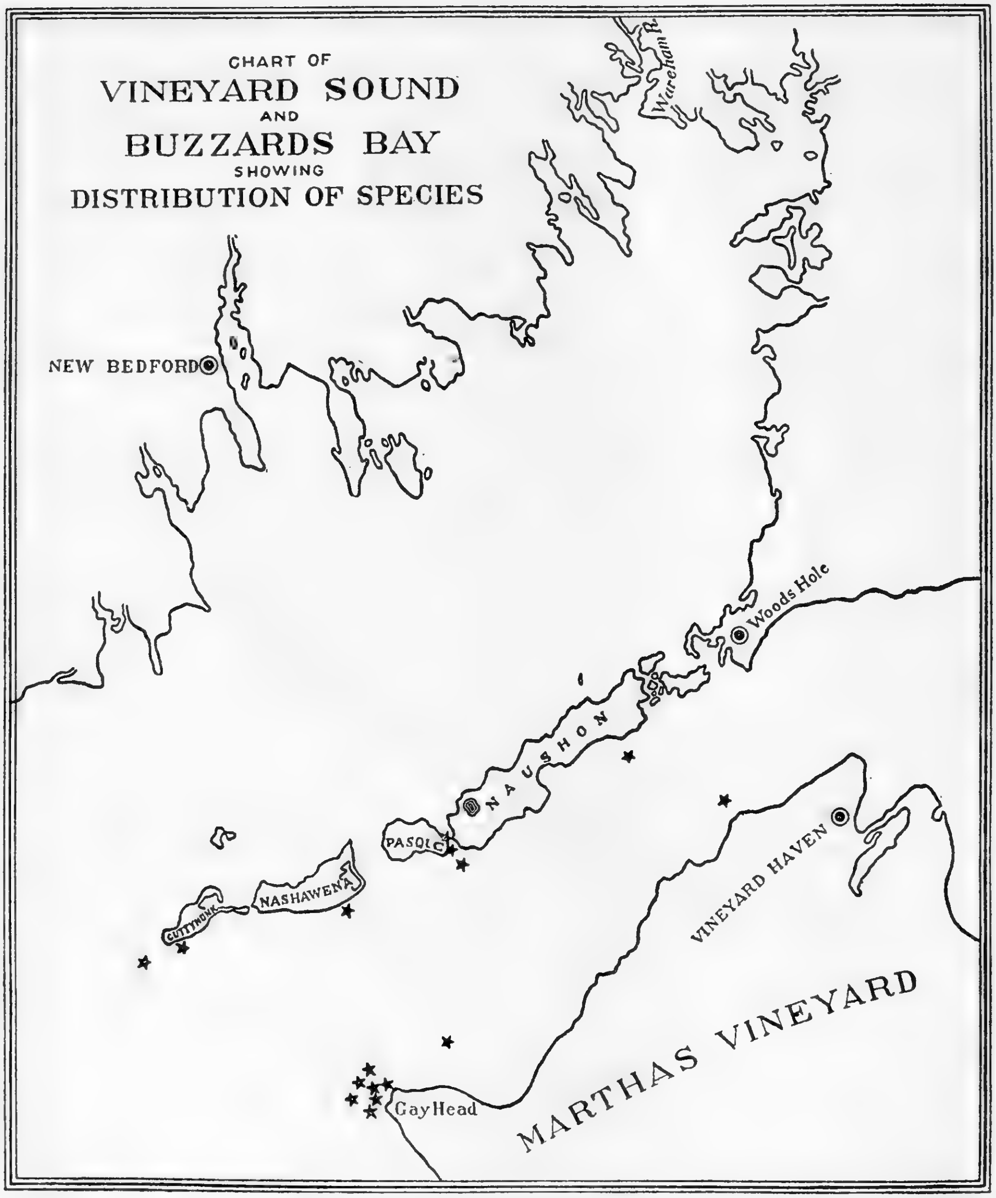

CHART 98.—Jassa marmorata.

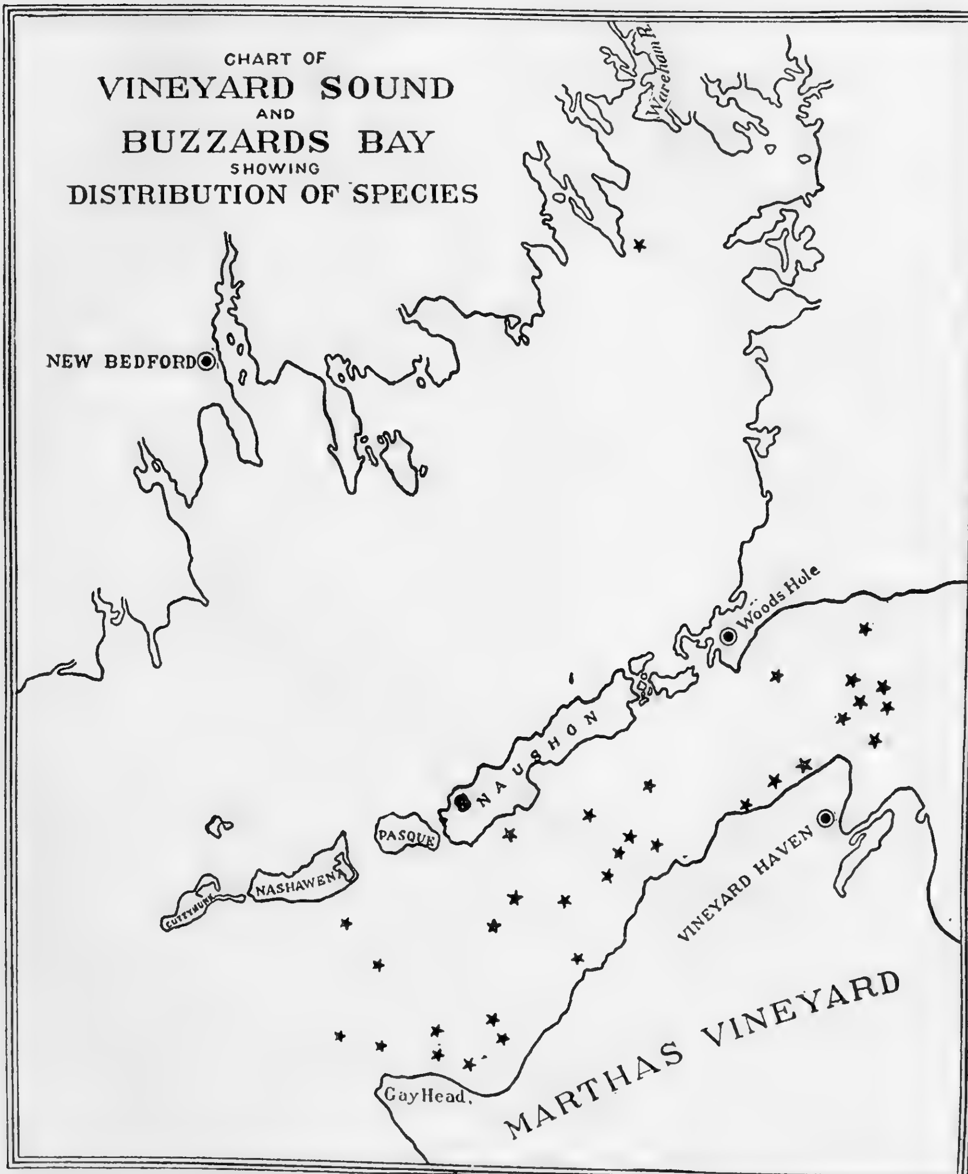

CHART 99.—Ericthonius minax.

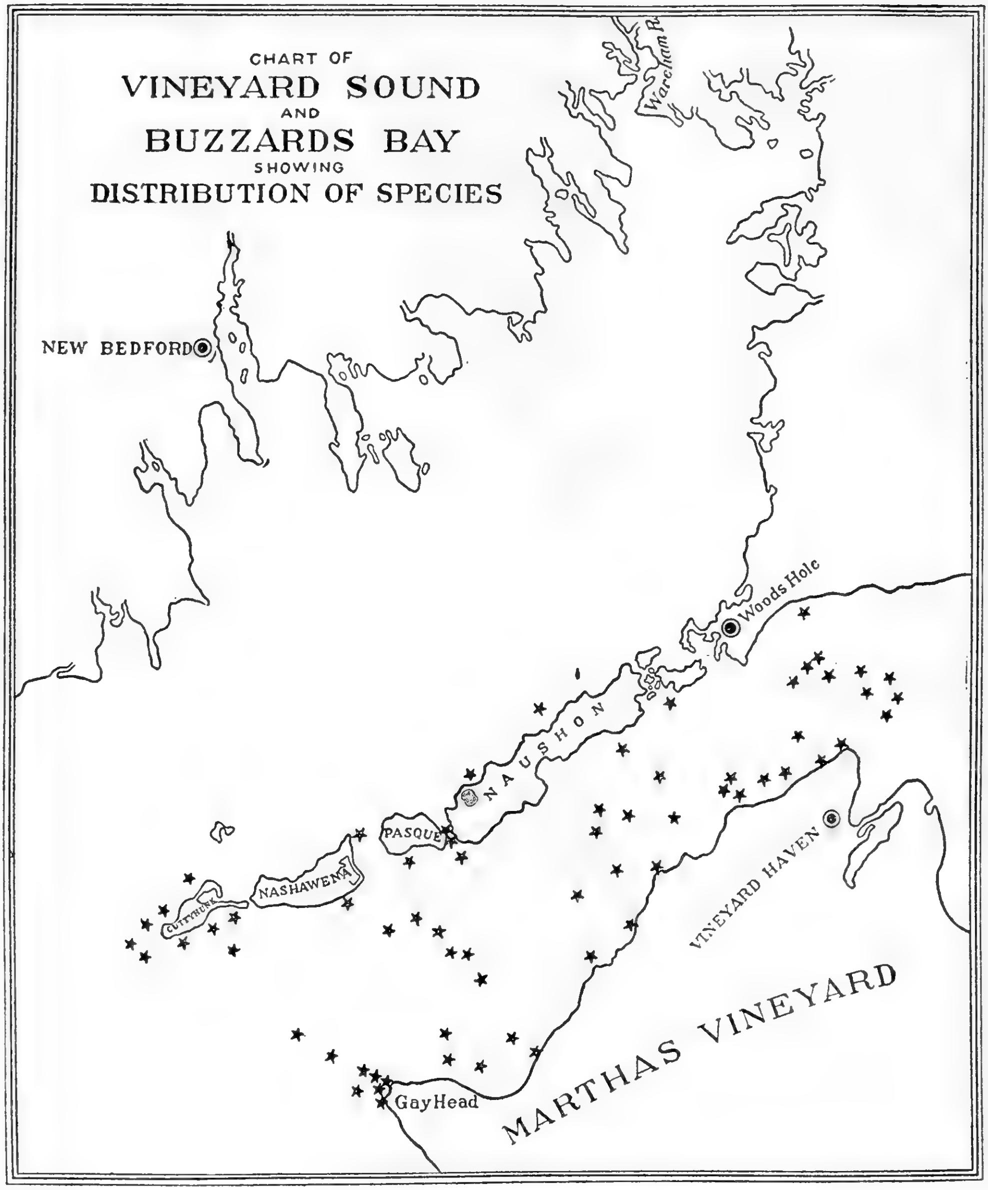

CHART 100.—Corophium cylindricum.

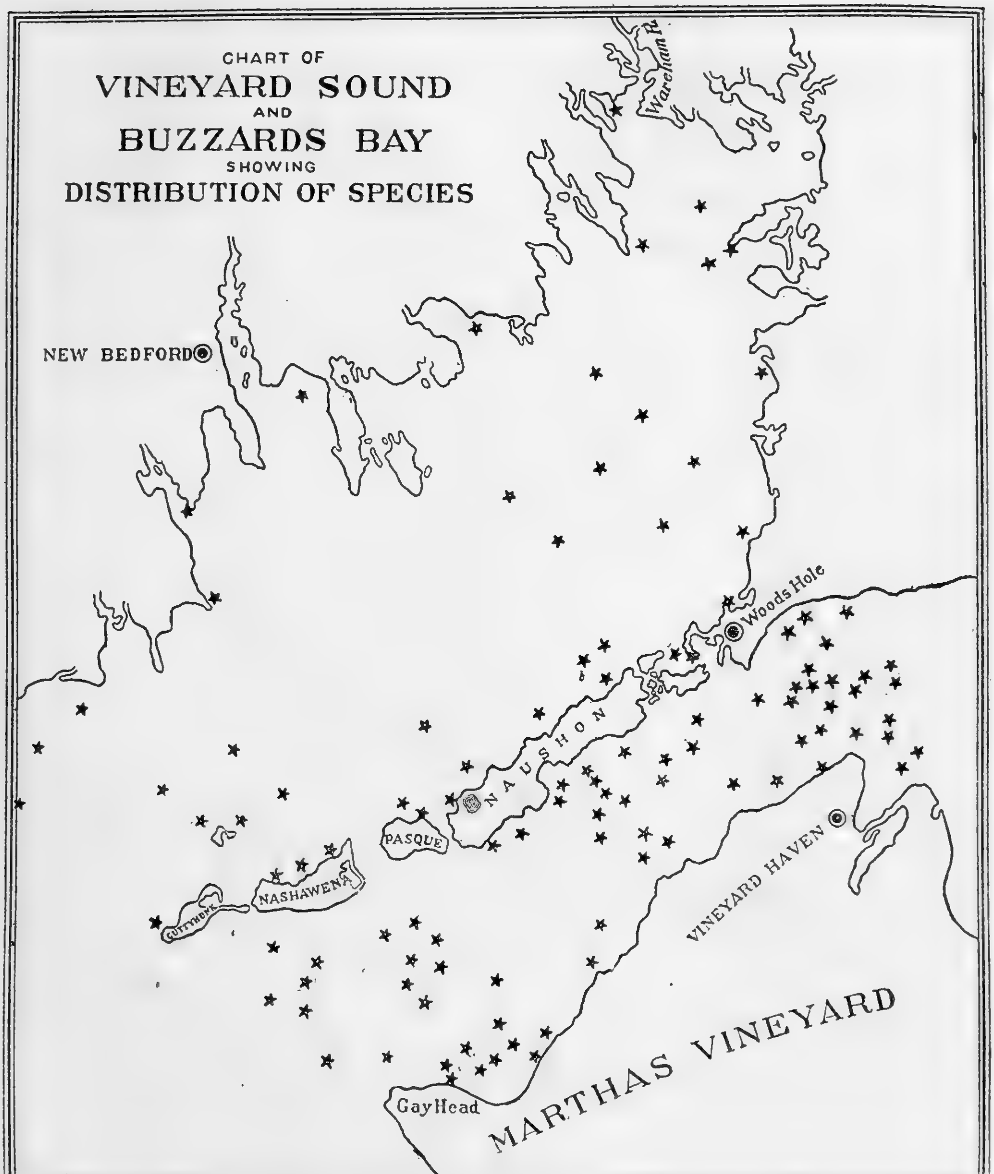

CHART 101.—Unciola irrorata.

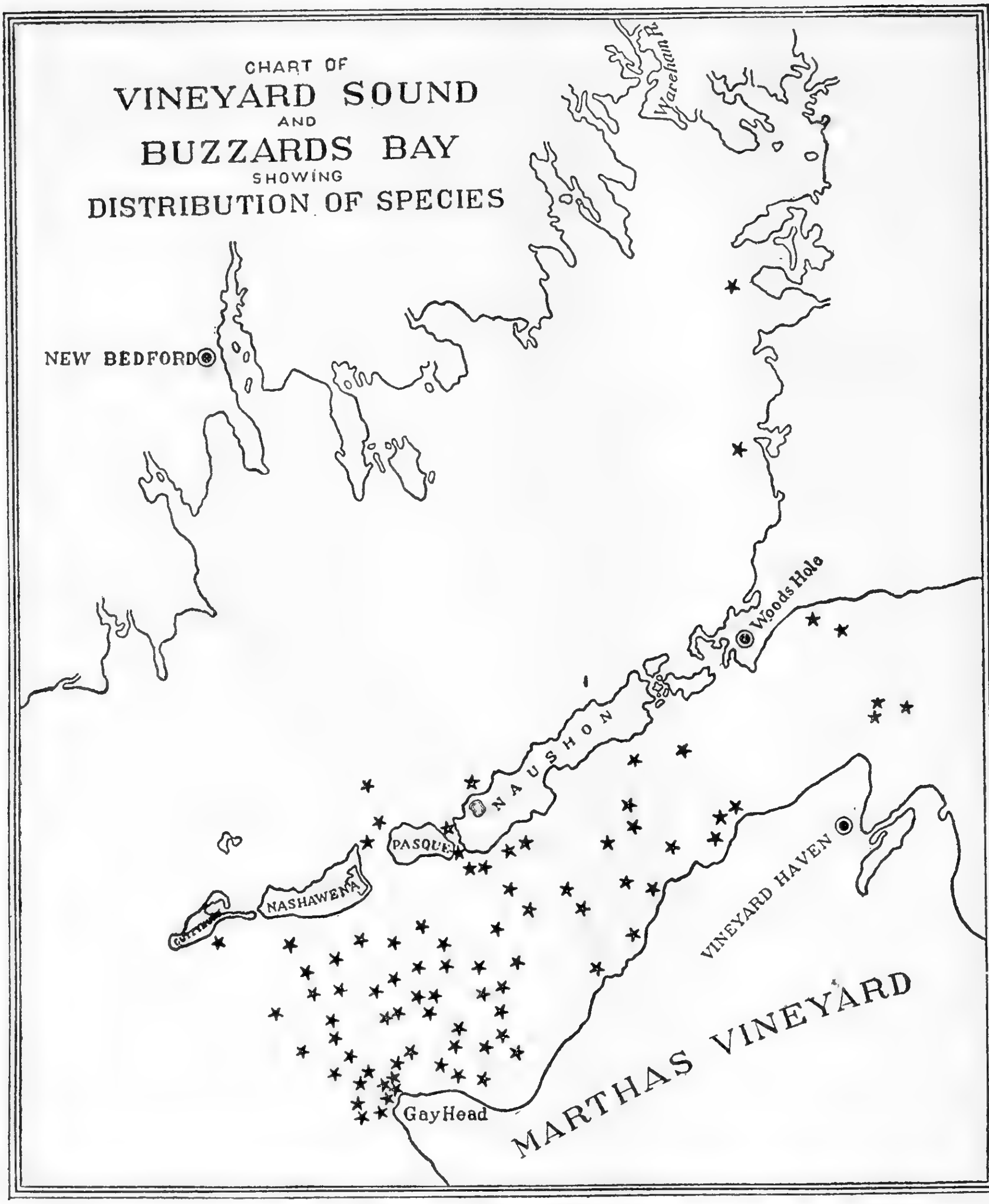

CHART 102.—Caprellidæ sp.

Owing to a confusion in the earlier records, the distributions of two members of this family (*Caprella geometrica* and *Æginella longicornis*), and possibly some others, have been plotted upon a single chart.

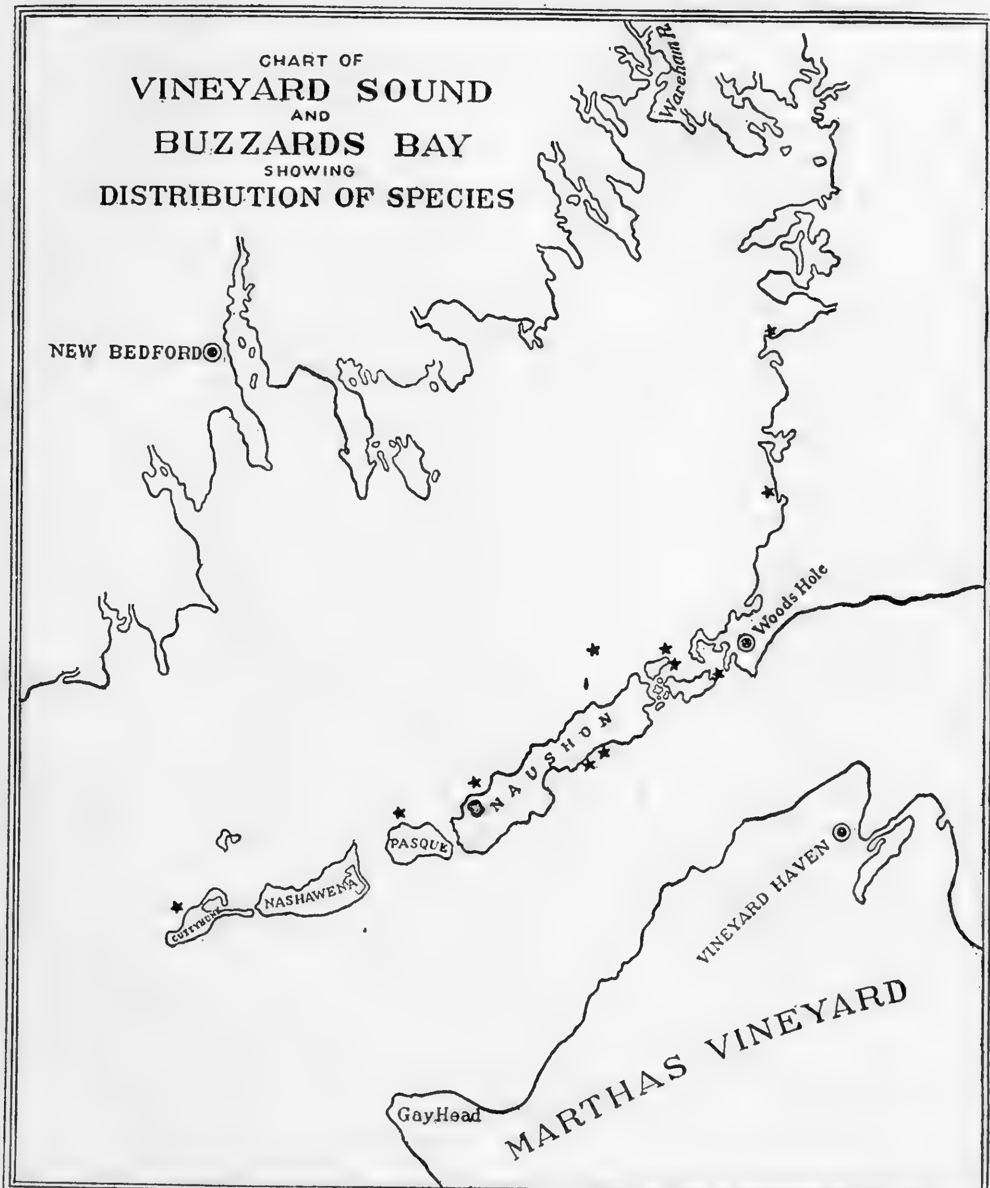

CHART 103.—Leptochelia savignyi.

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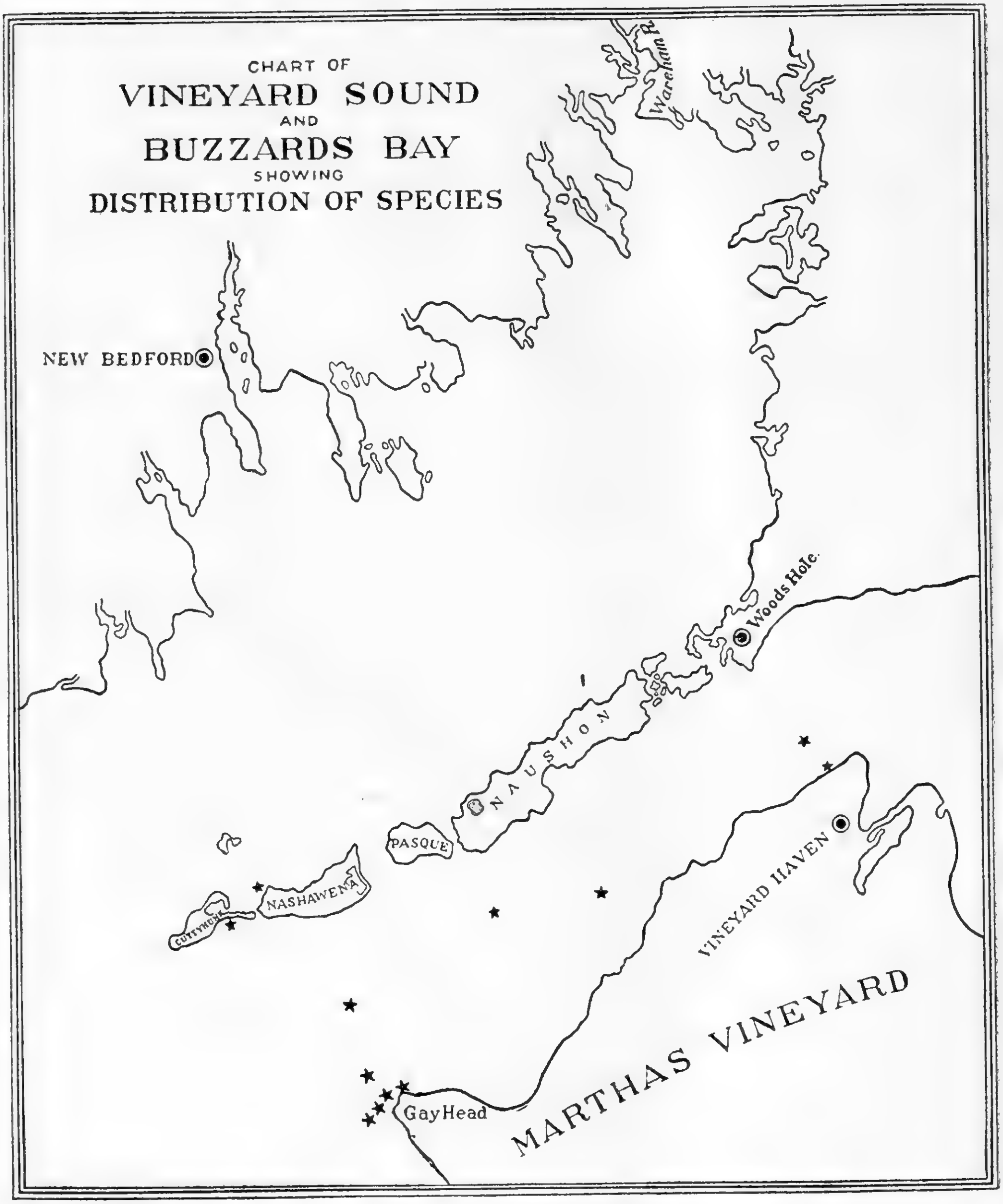


CHART 104.—Idothea baltica.

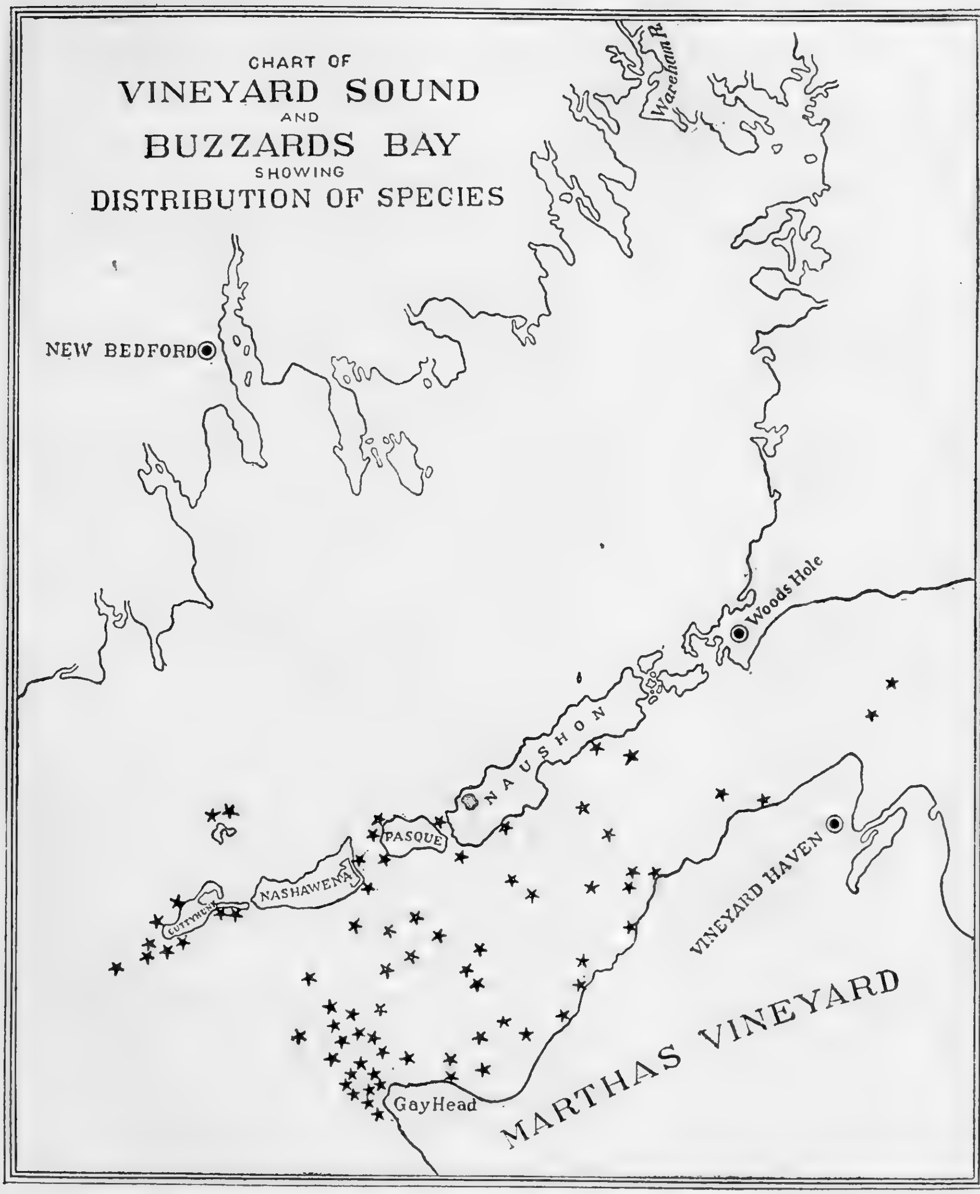


CHART 105.—Idothea phosporea.

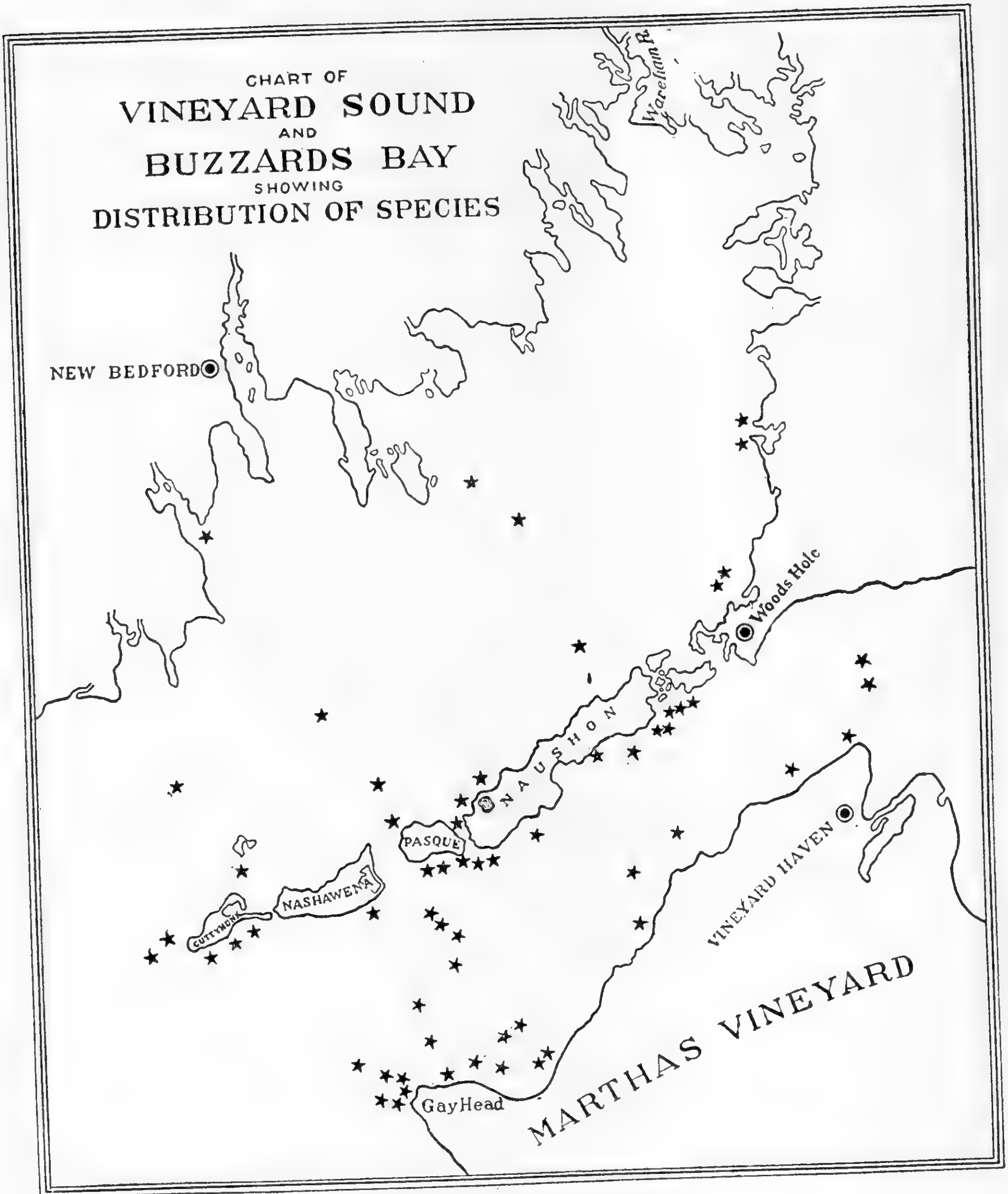


CHART 106.—Erichsonella filiformis.

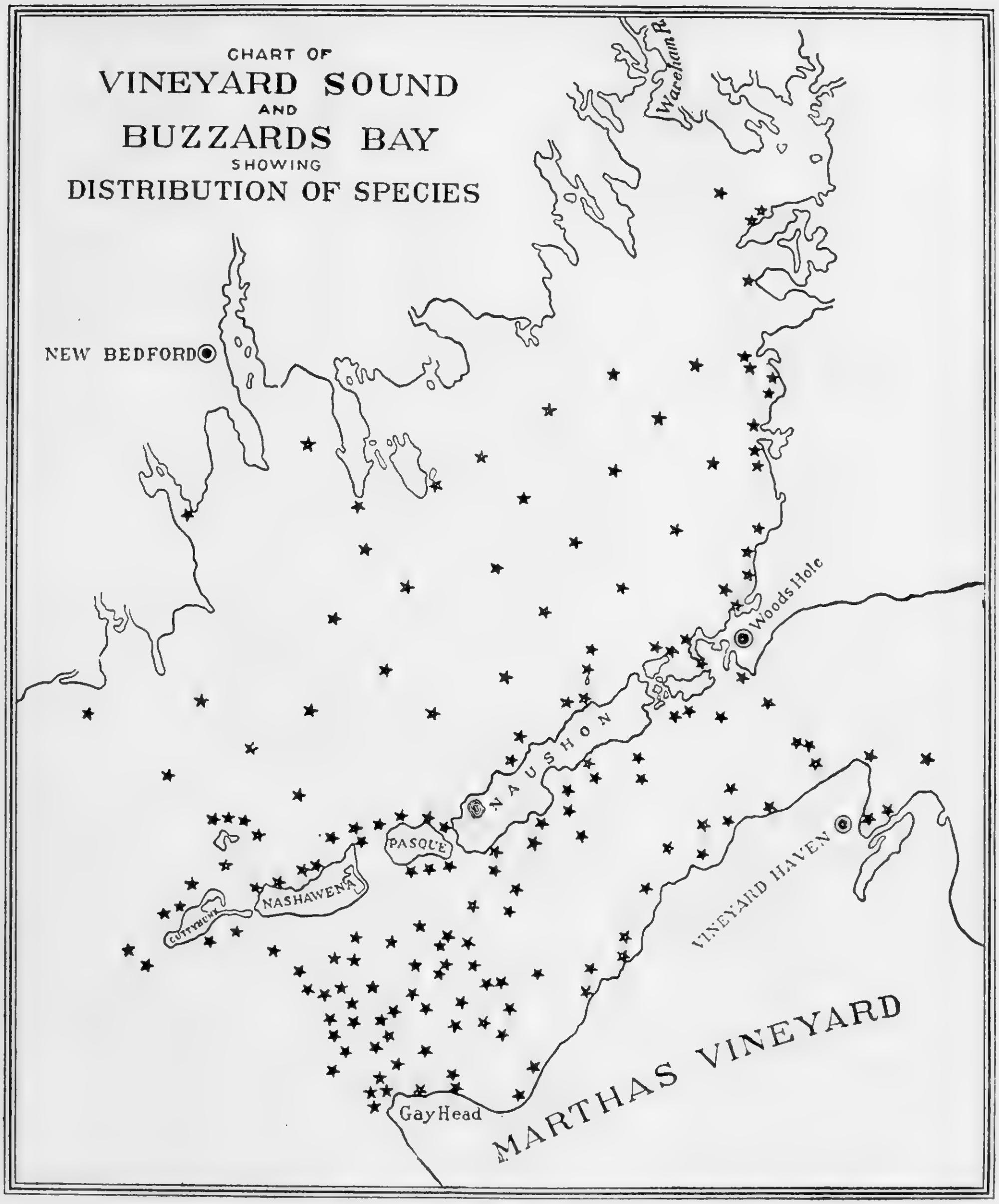


CHART 107.—Crago septemspinosus.

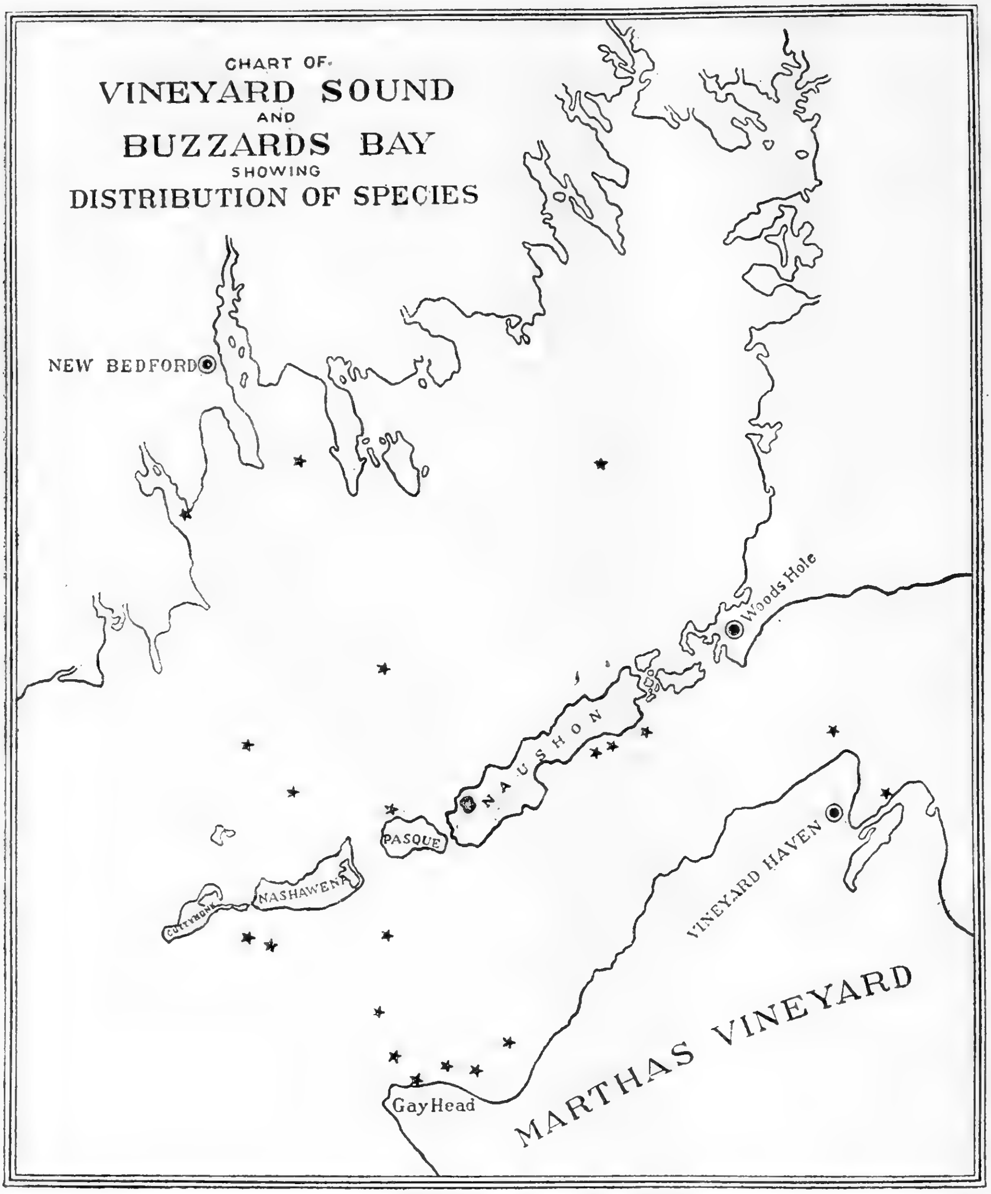


CHART 108.—Homarus americanus.

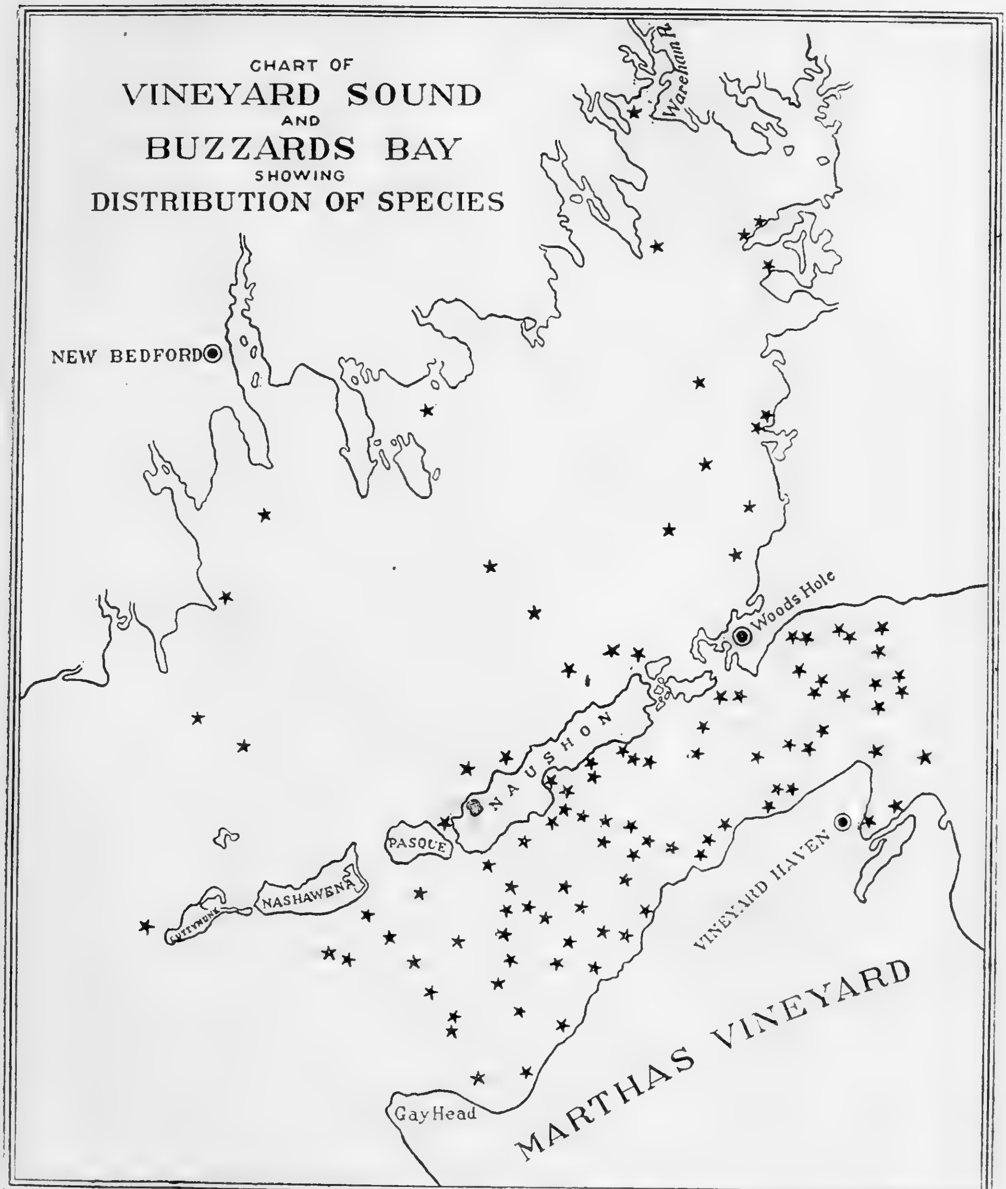


CHART 109.—Pagurus pollicaris.

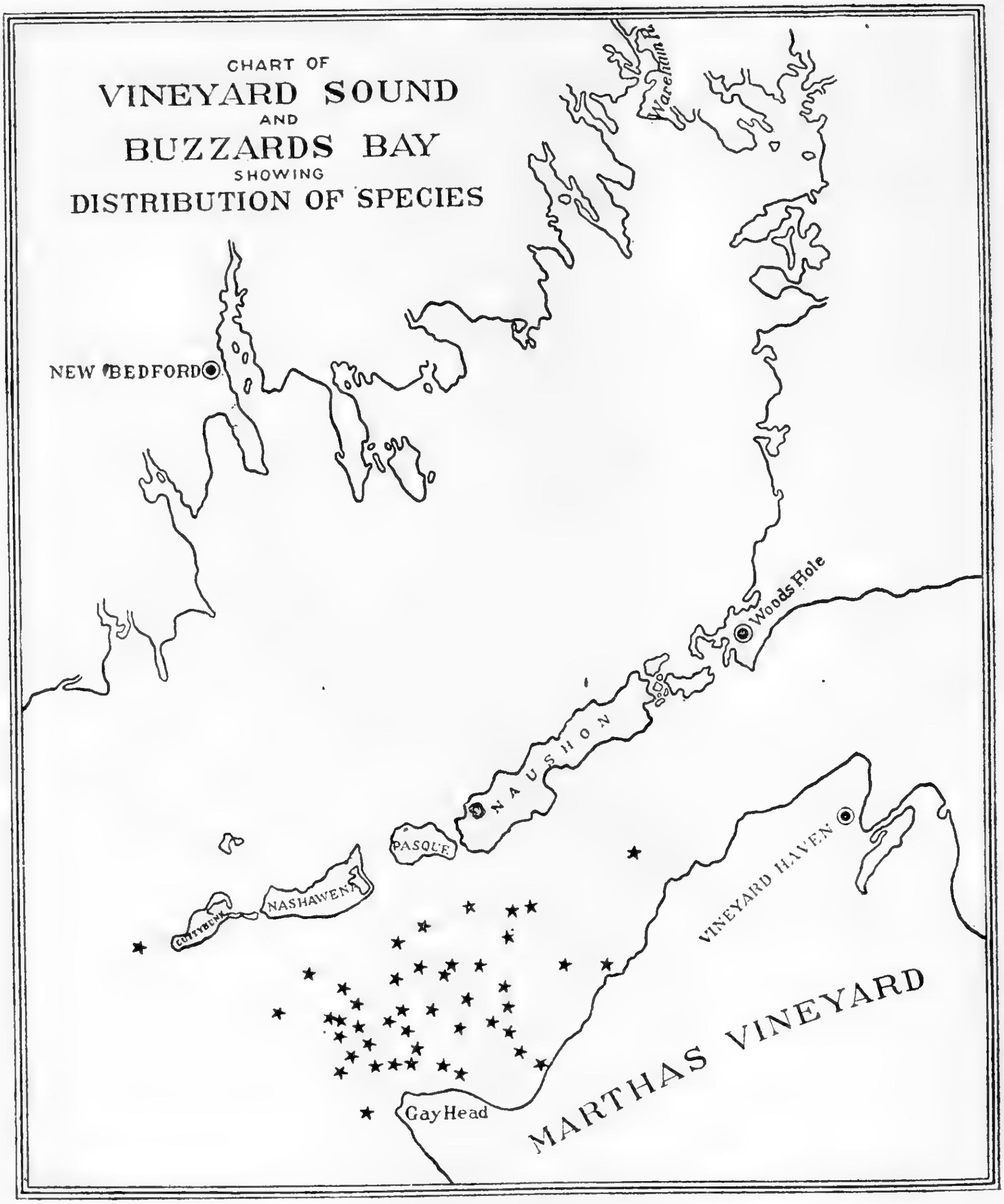


CHART 110.—Pagurus acadianus.

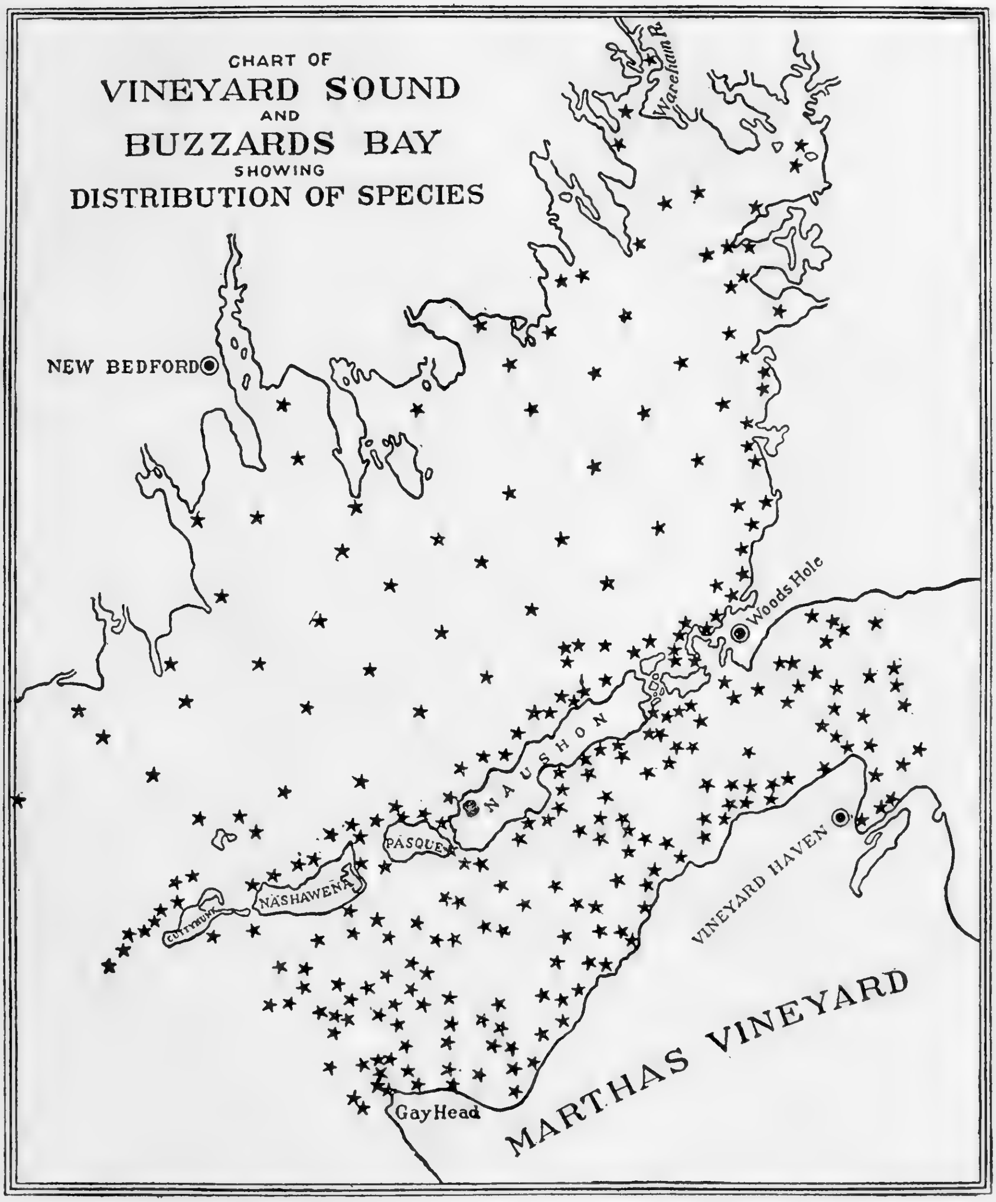


CHART 111.—Pagurus longicarpus.

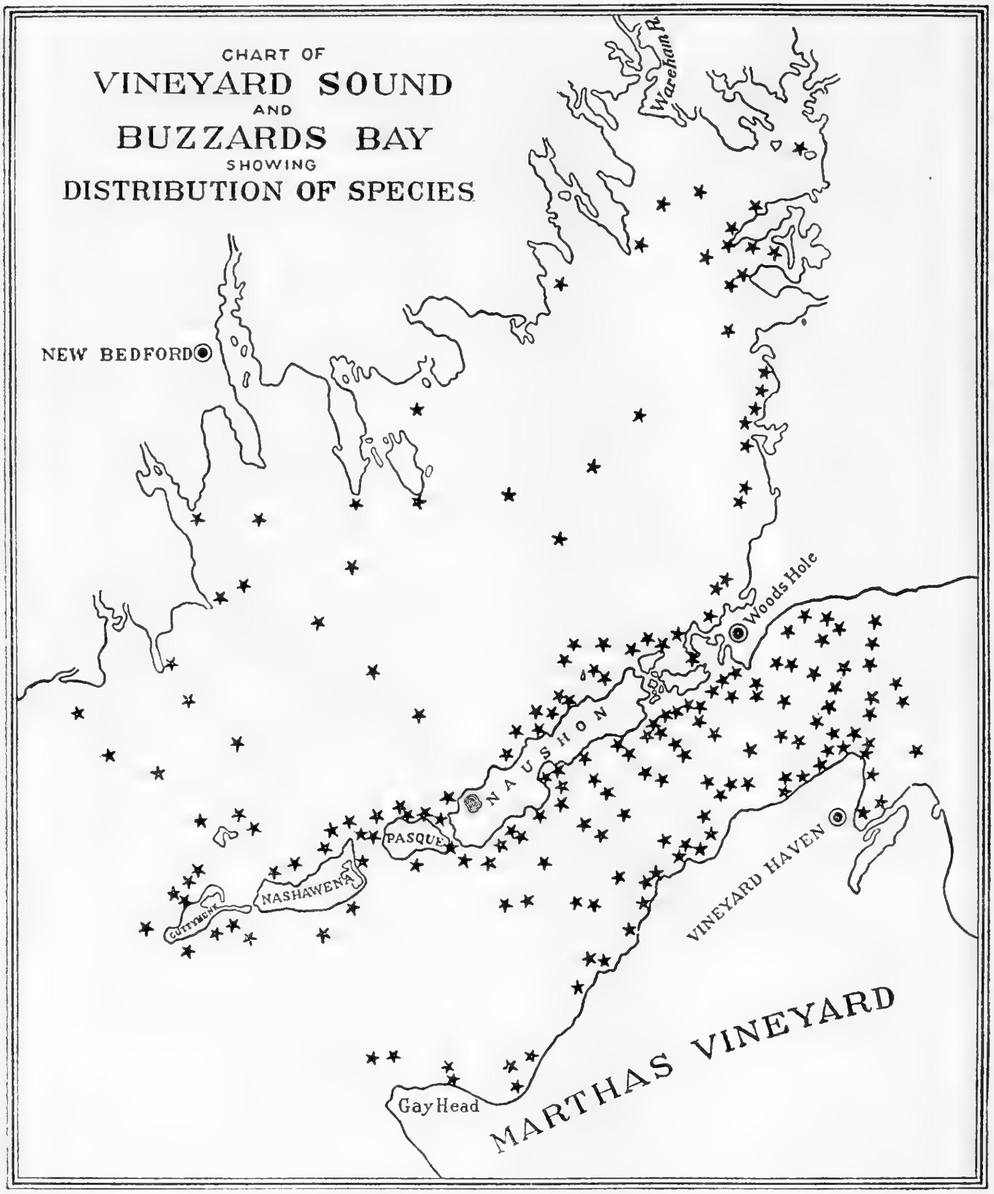


CHART 112.—Pagurus annulipes.

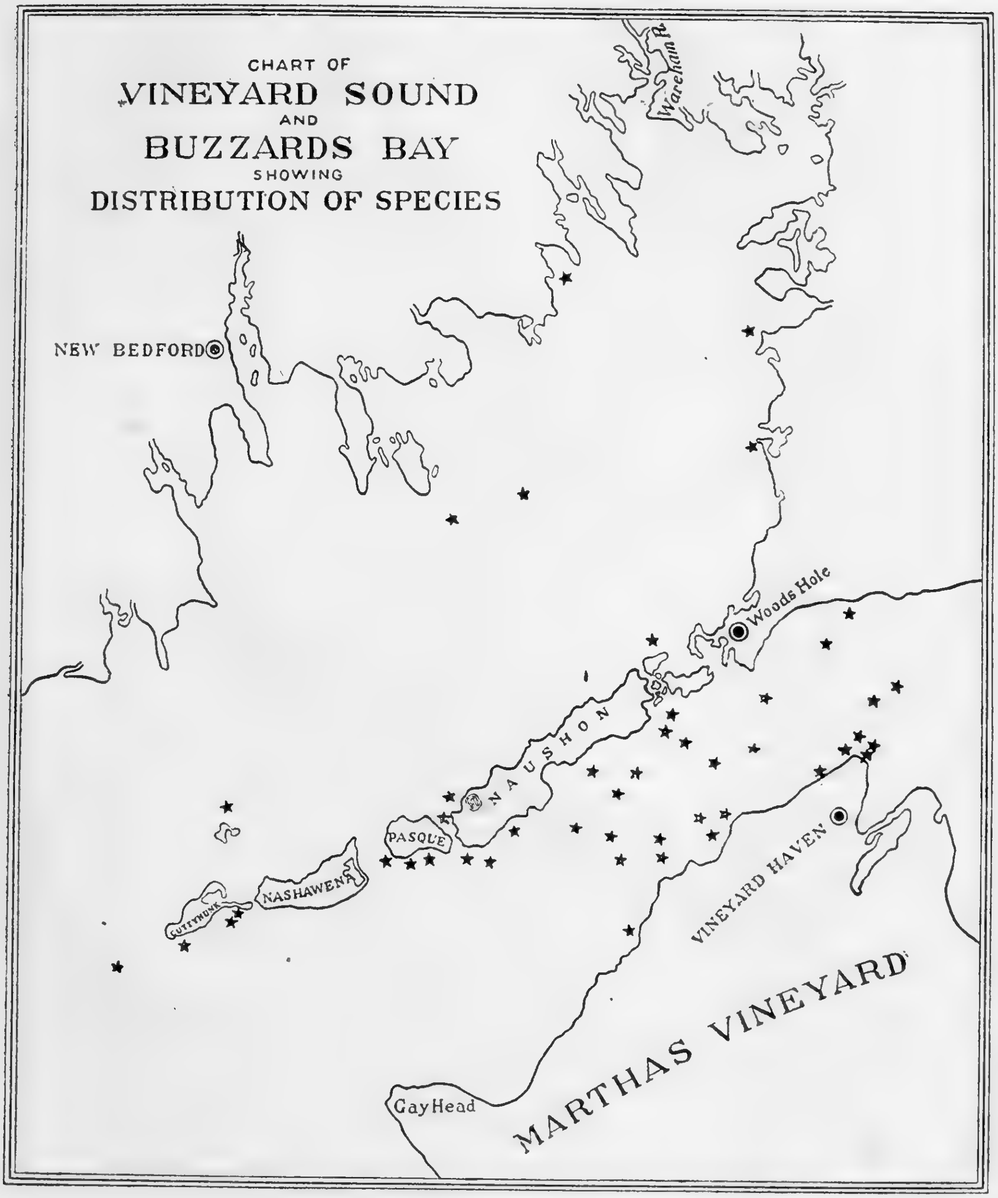


CHART 113.—Pelia mutica.

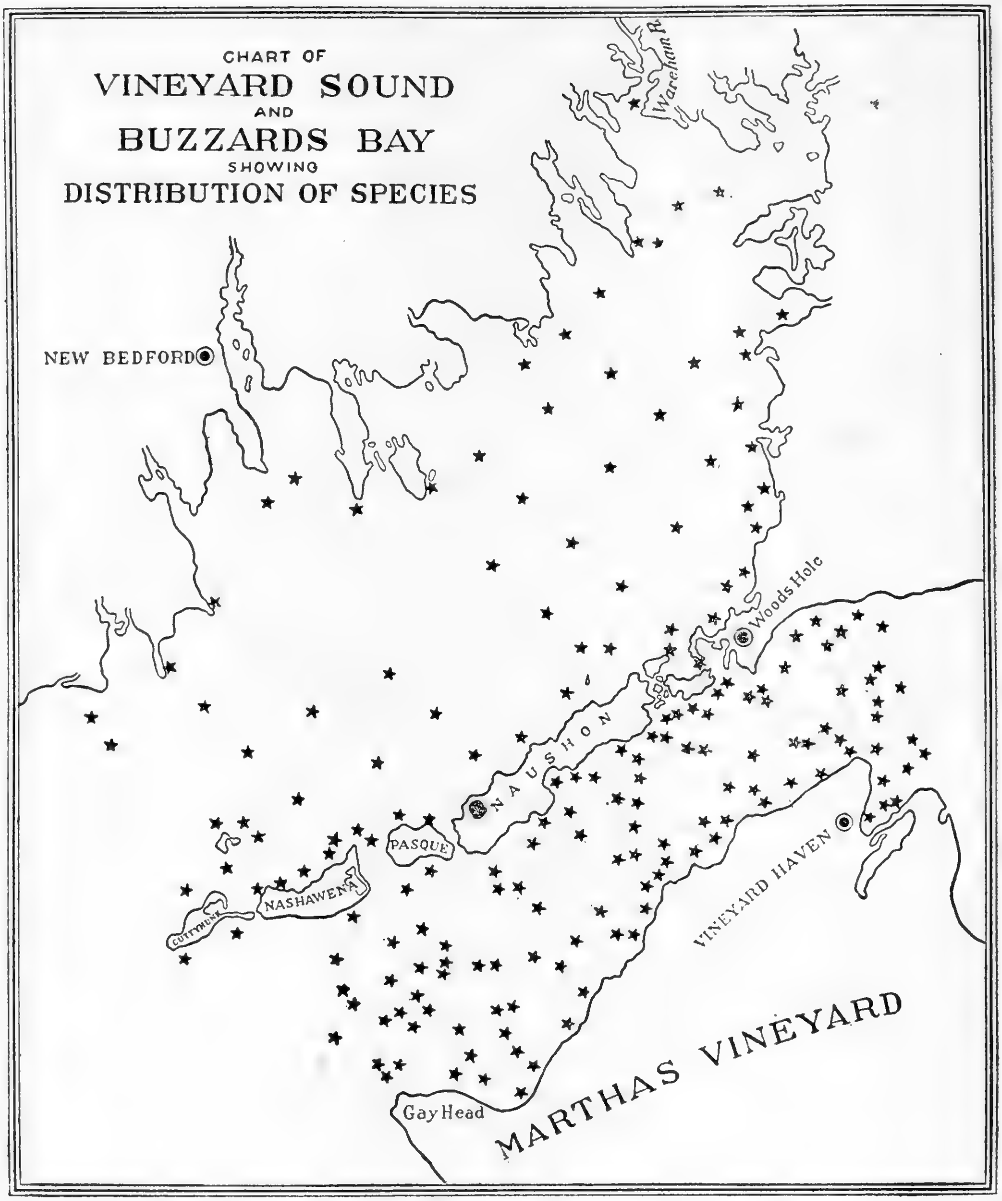


CHART 114.—Libinia emarginata.

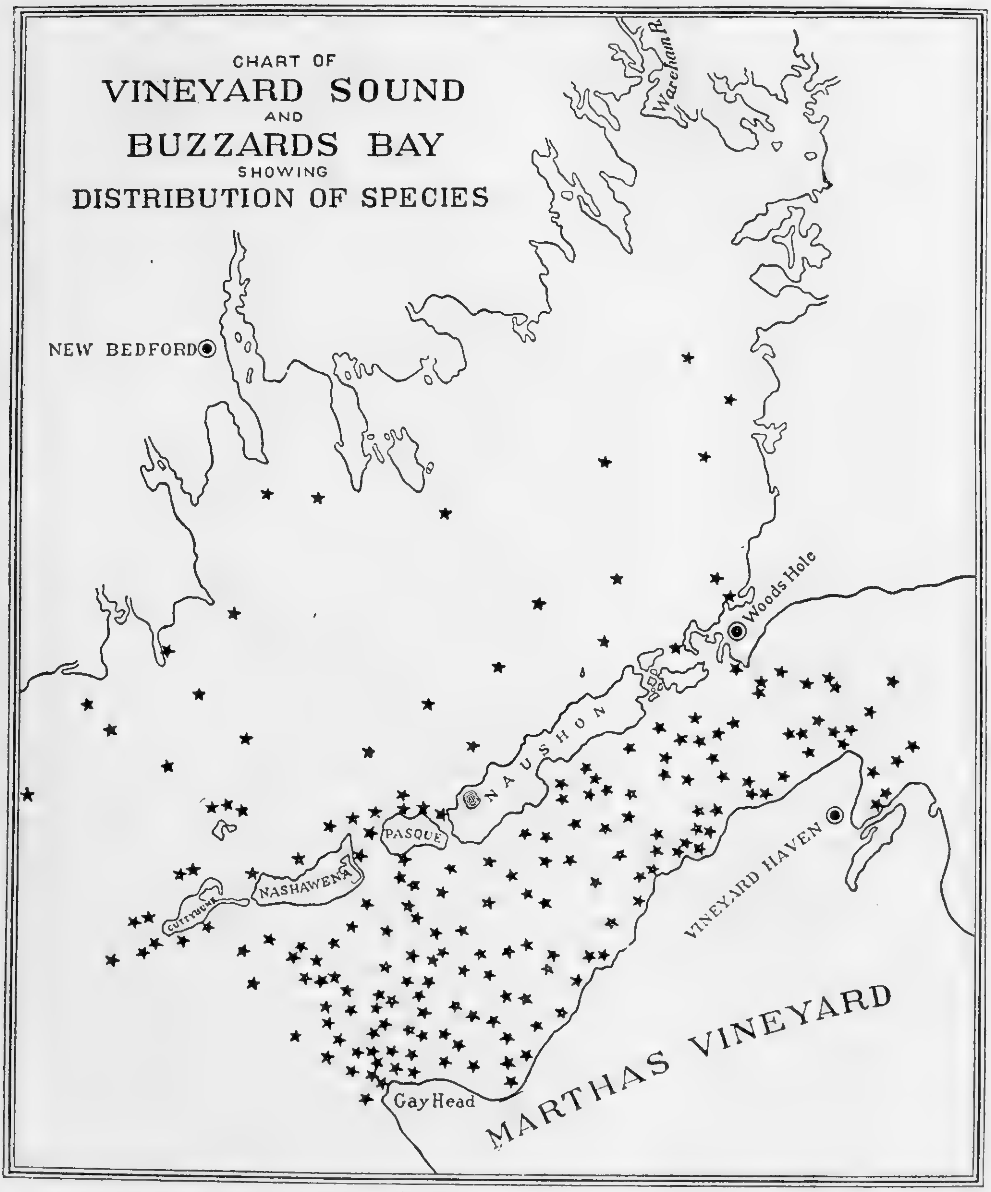


CHART 115.—Cancer irroratus.

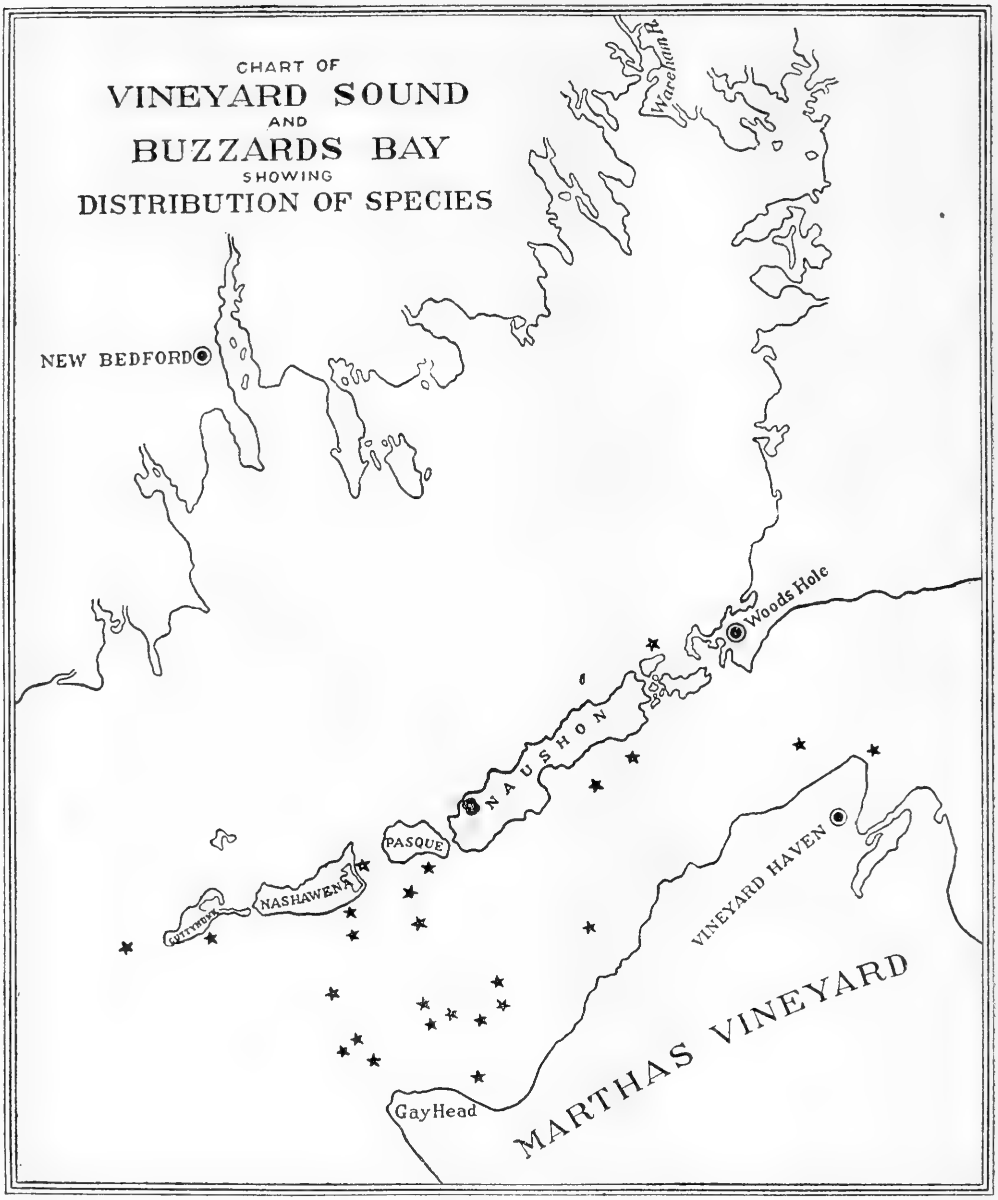


CHART 116.—Cancer borealis.

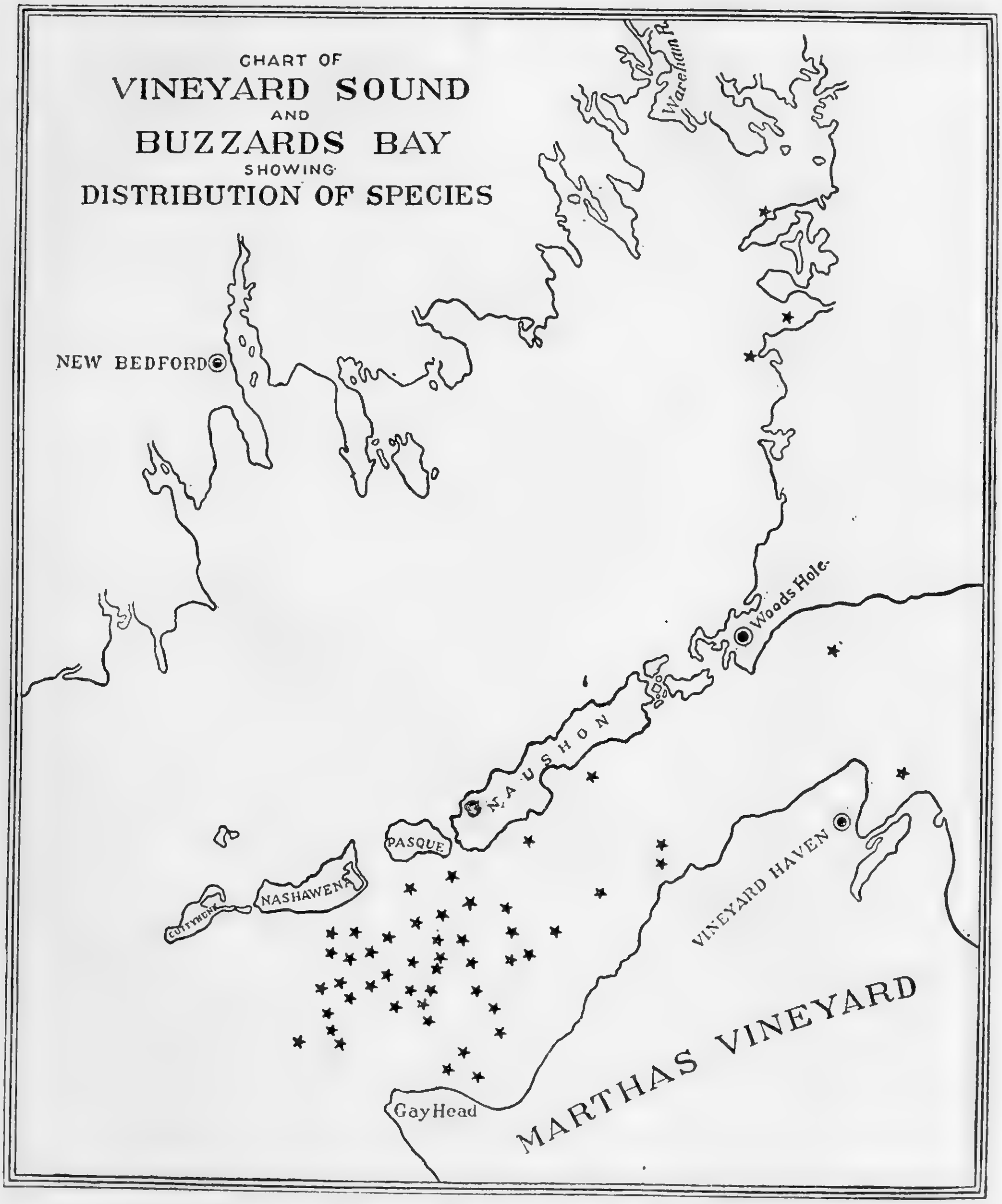


CHART 117.—Ovalipes ocellatus.

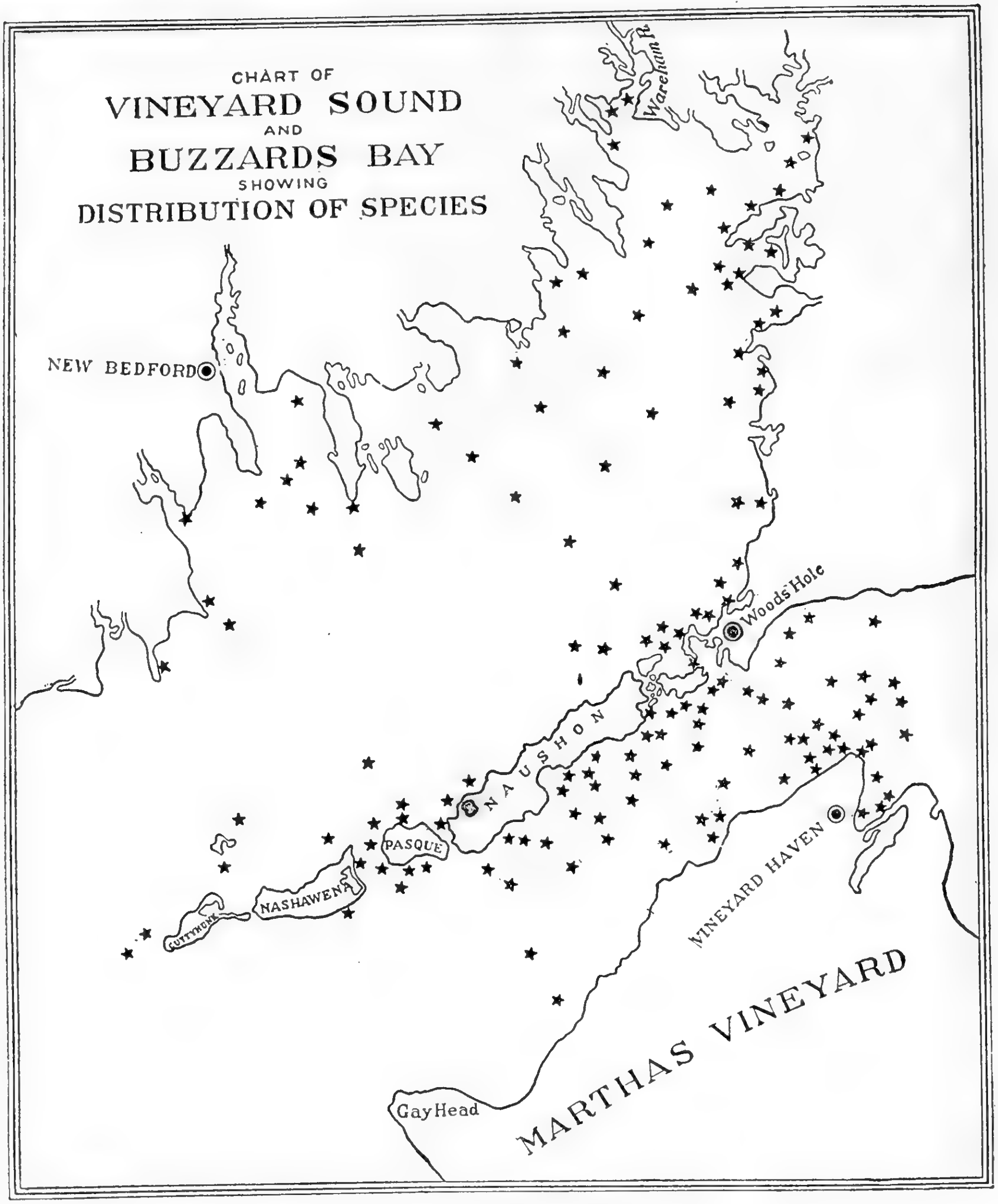


CHART 118.—Neopanope texana sayi.

CHART 119.—Pinnotheres maculatus.

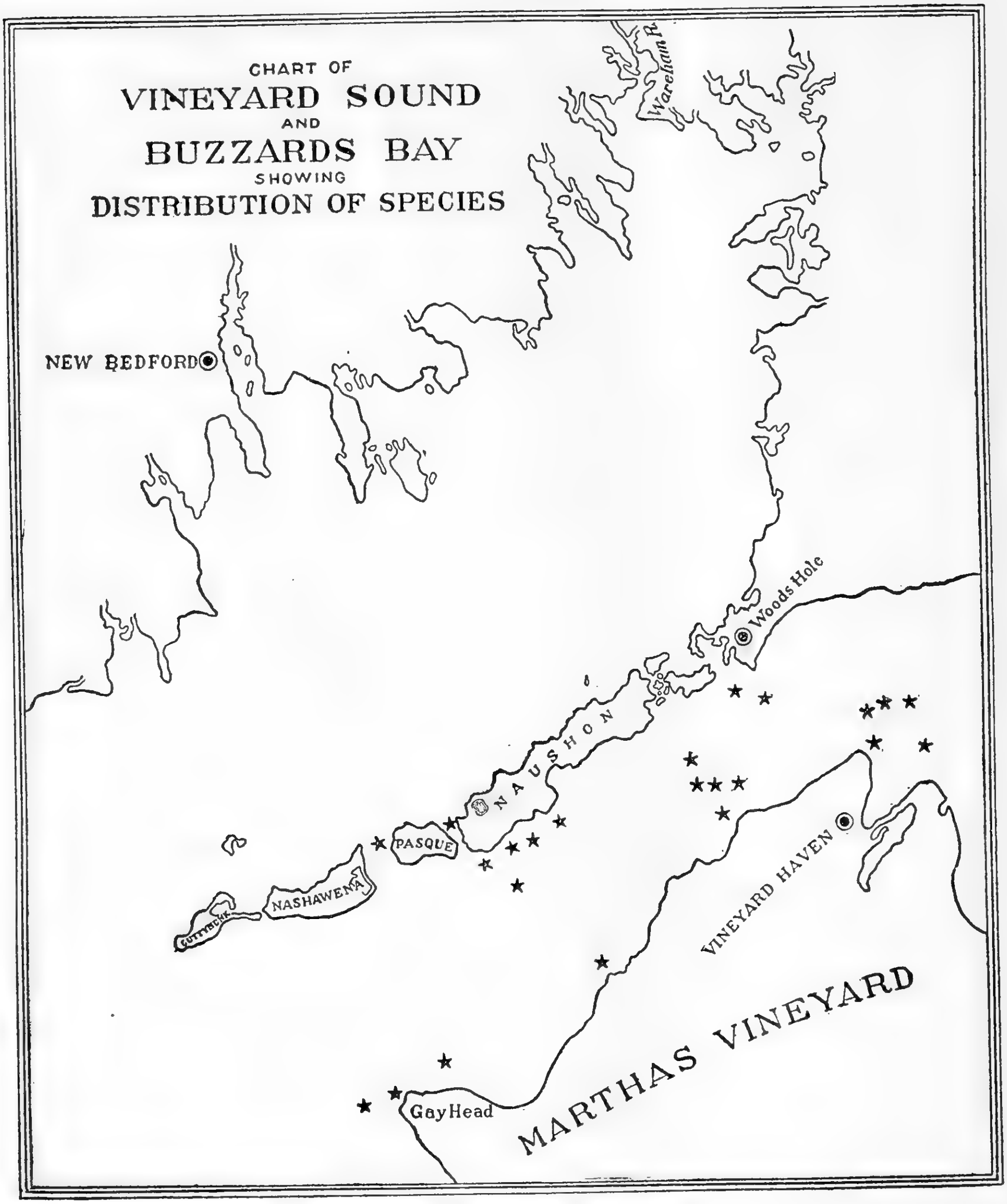


CHART 120.—Tanystylum orbiculare.

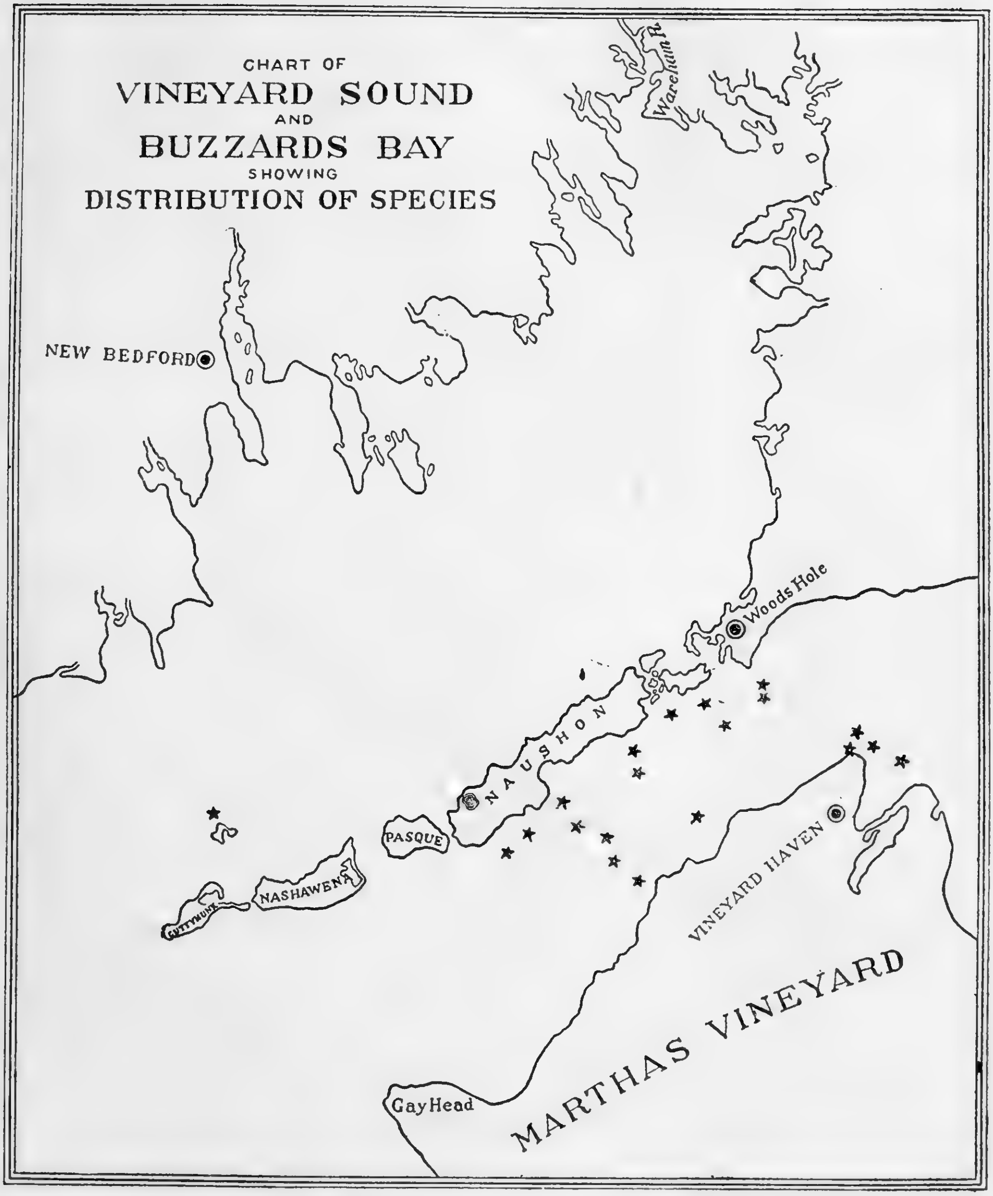


CHART 121.—Anoplodactylus lentus.

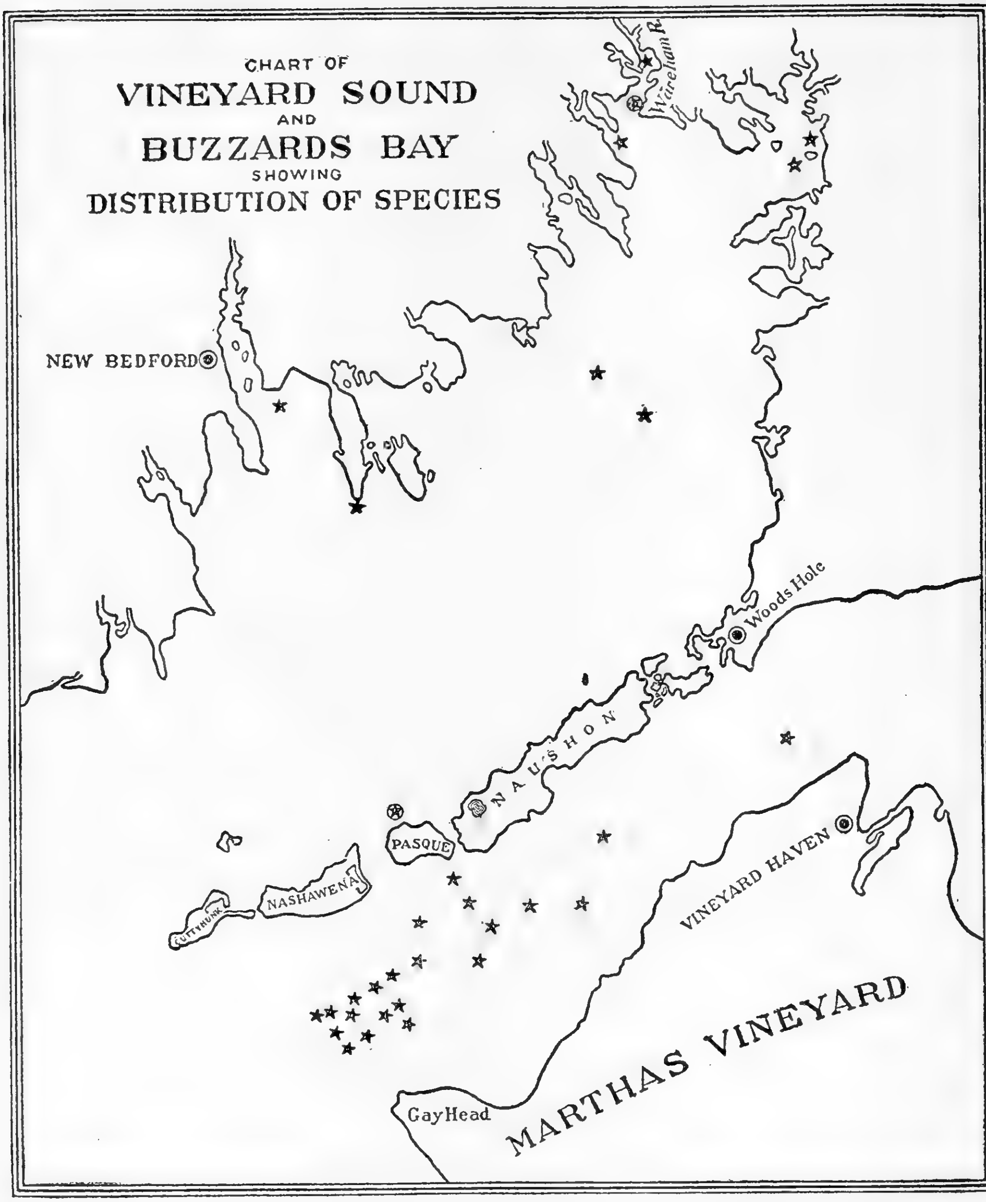


CHART 122.—Ostrea virginica. (See explanation of chart 26.)

The distribution pattern for the oyster, as here portrayed, is largely a spurious one, due to the occurrence of shells thrown overboard from passing vessels.

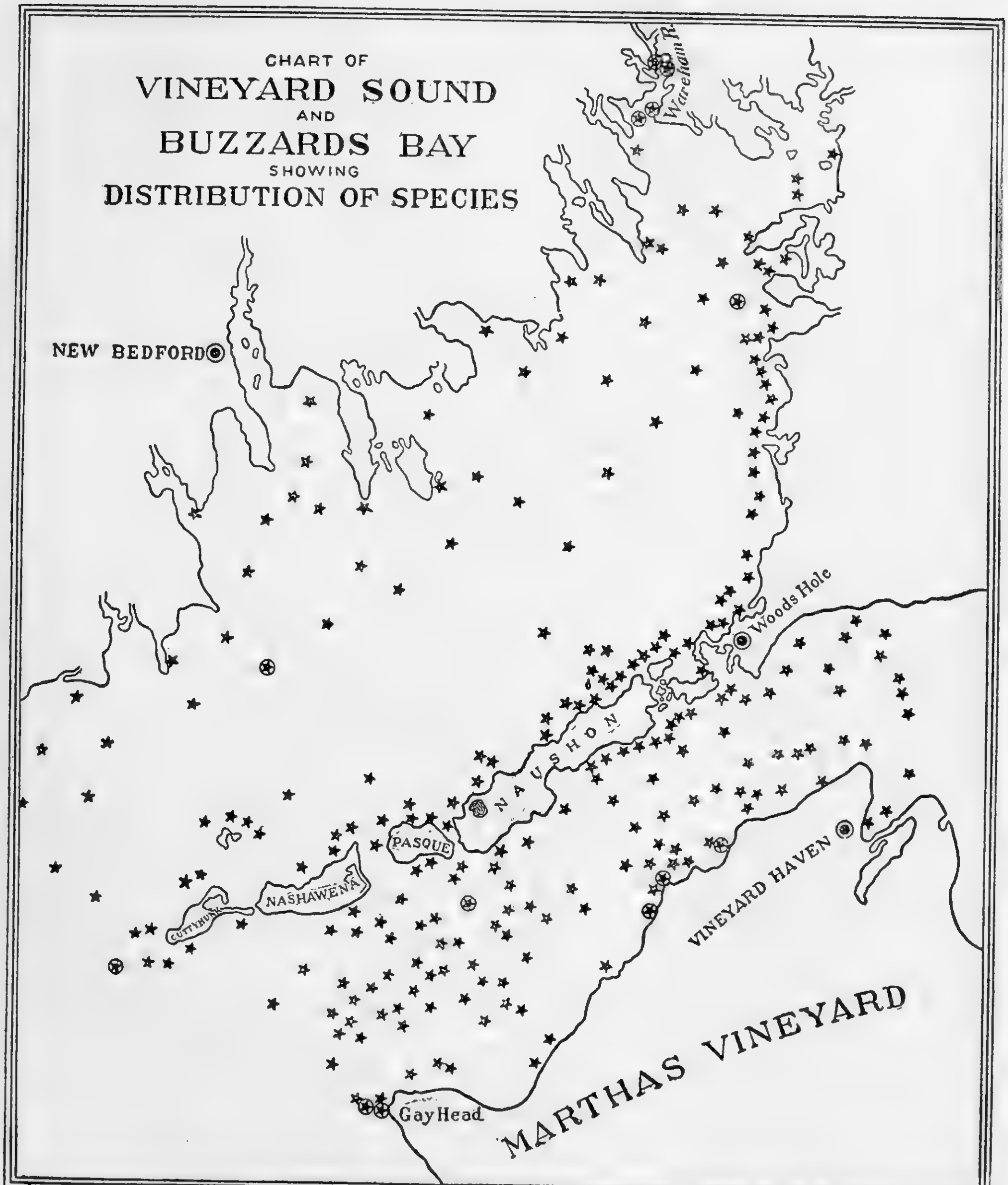


CHART 123.—Anomia simplex. (See explanation of chart 26.)

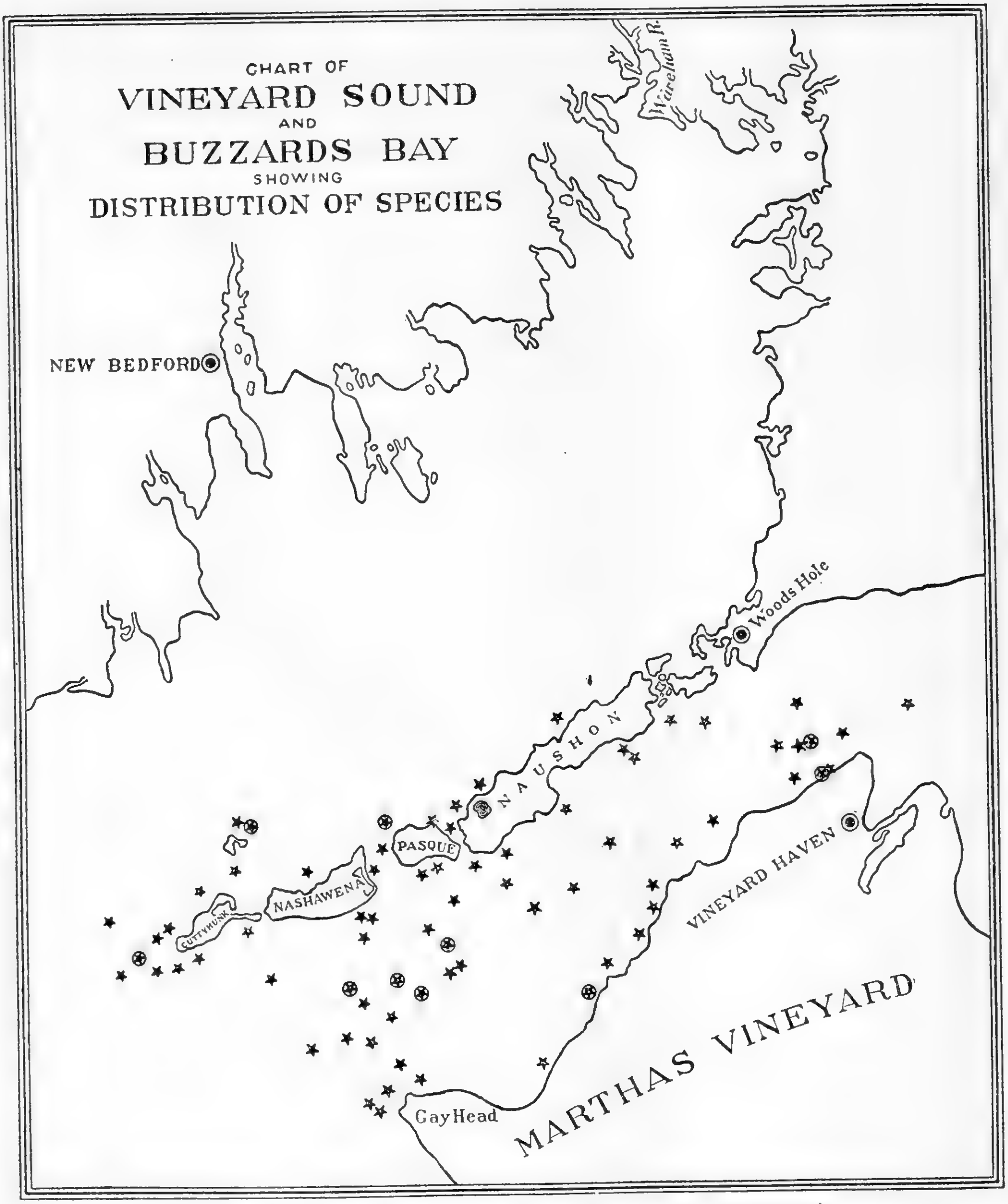


CHART 124.—Anomia aculeata. (See explanation of chart 26.)

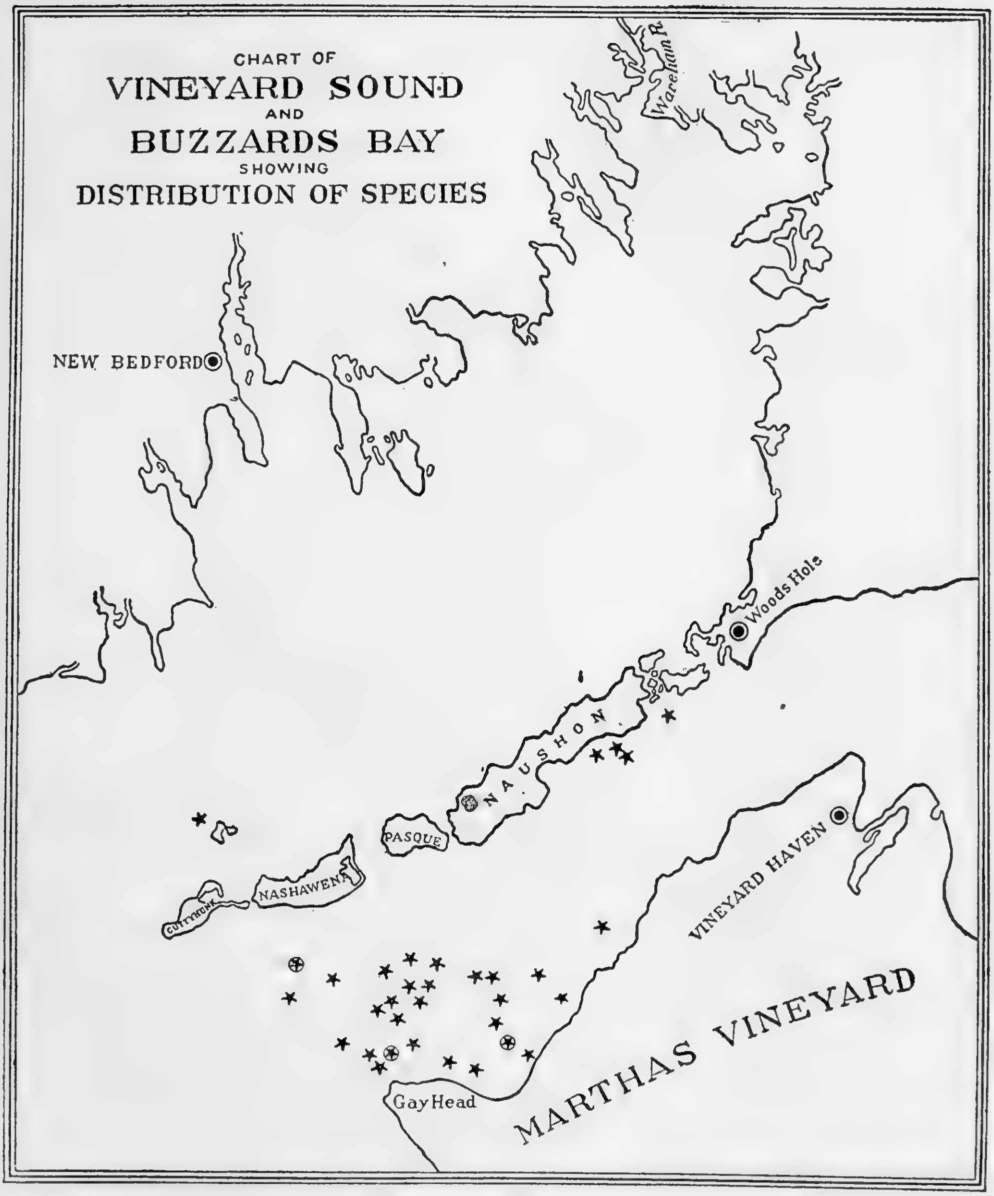


CHART 125.—Pecten magellanicus. (See explanation of chart 26.)

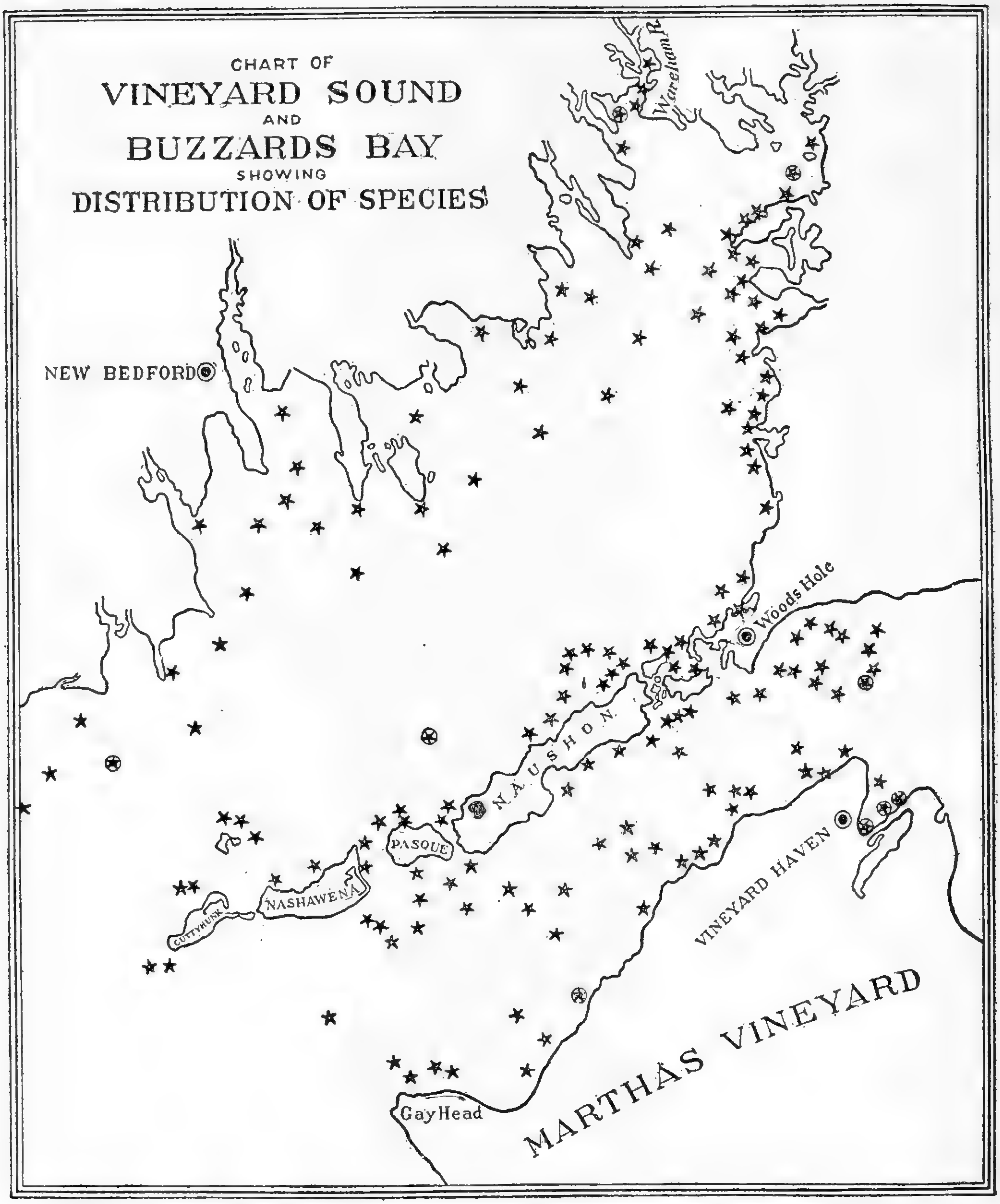


CHART 126.—Pecten gibbus borealis. (See explanation of chart 26.)

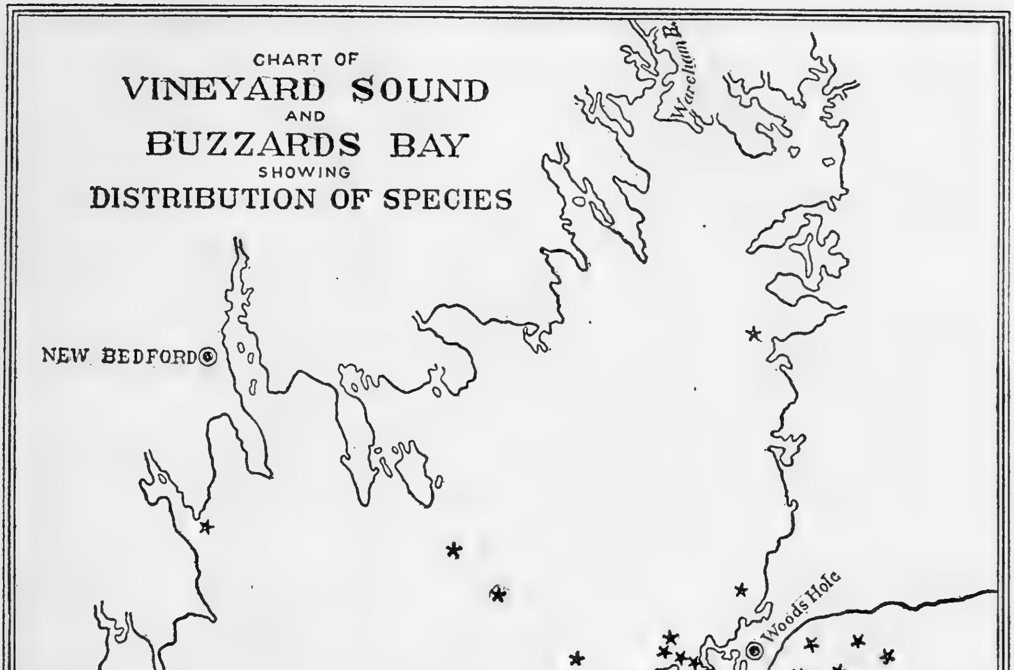


CHART 127.—Mytilus edulis. (See explanation of chart 26.)

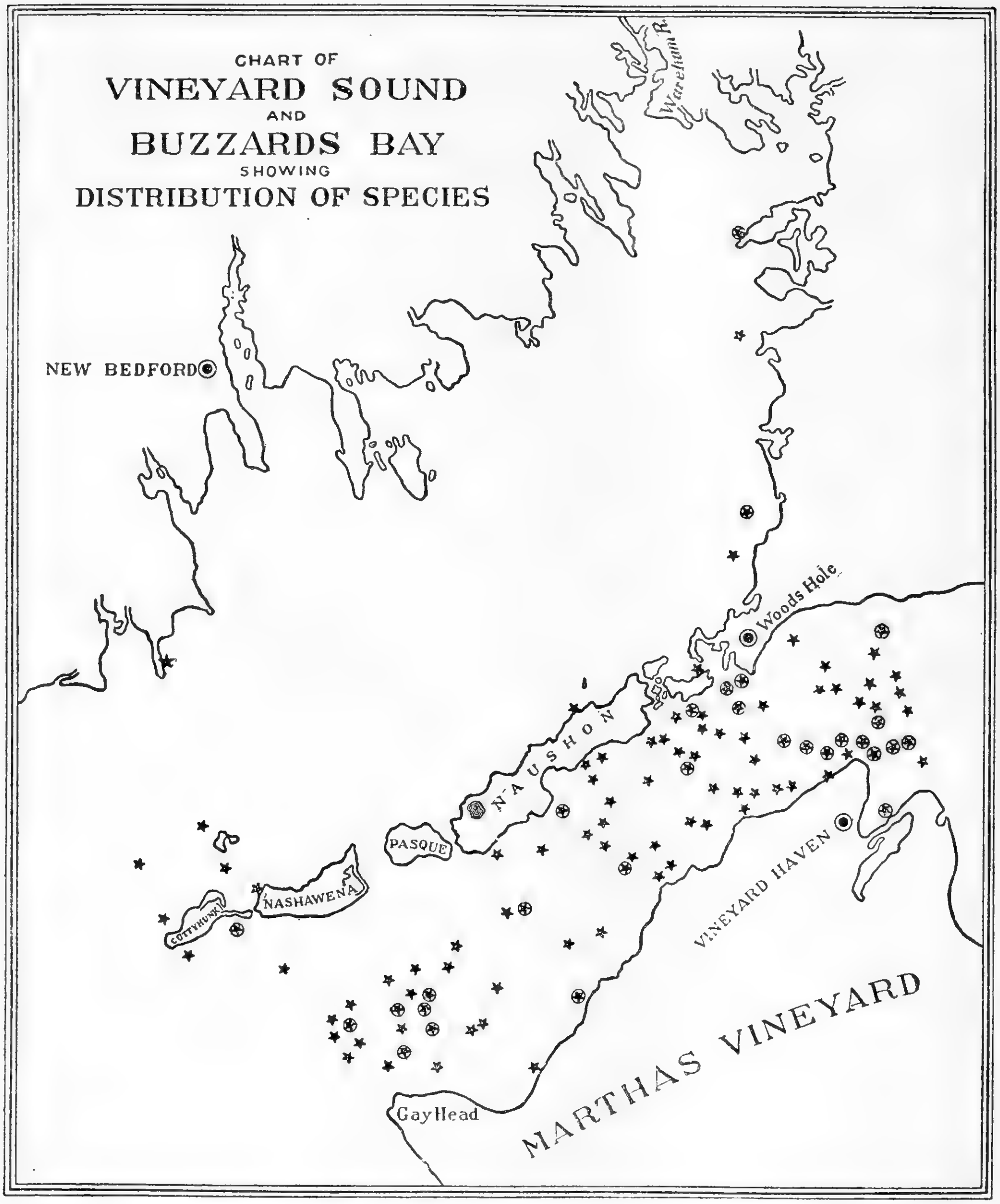


CHART 128.—Modiolus modiolus. (See explanation of chart 26.)

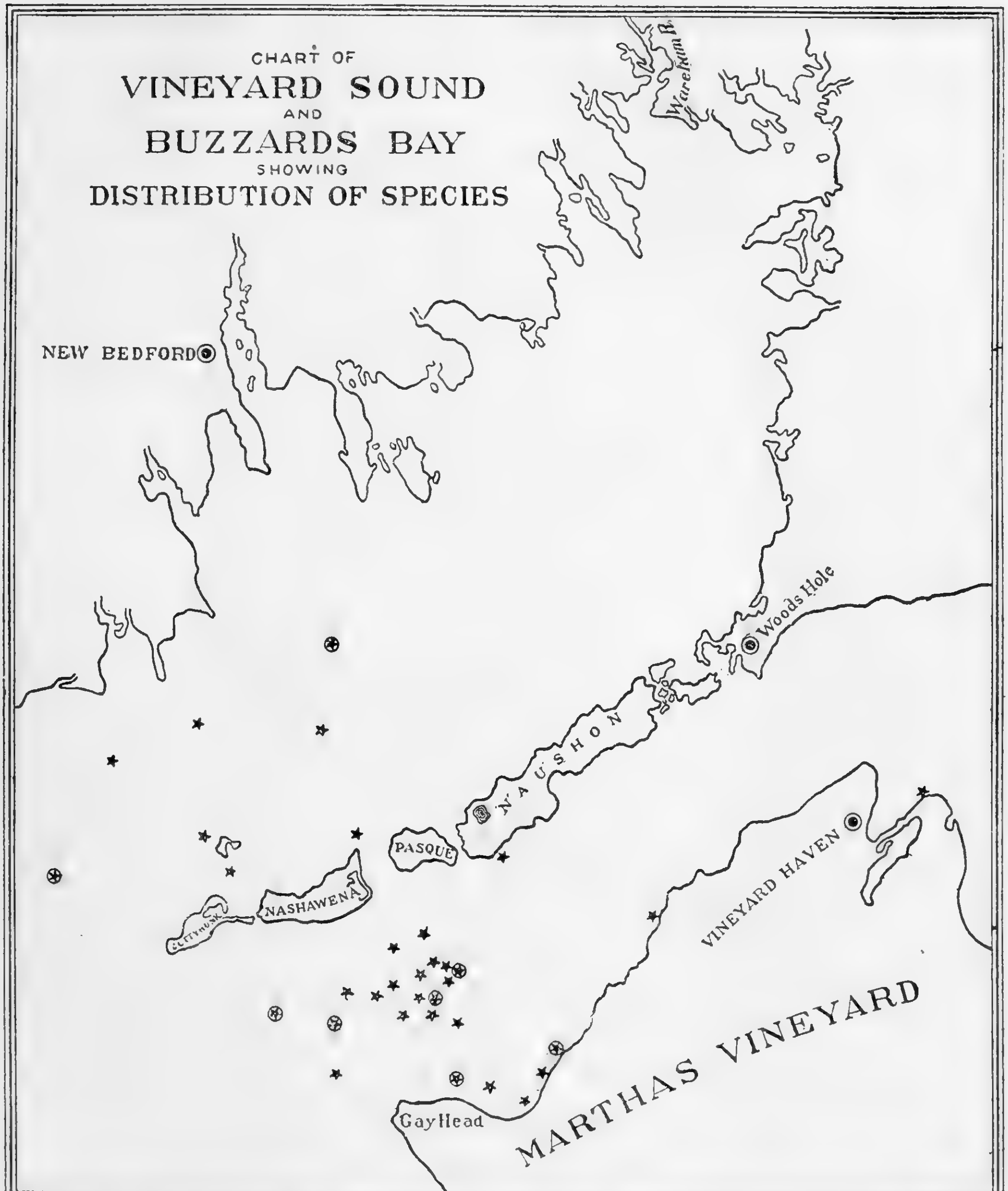


CHART 129.—Modiolaria nigra. (See explanation of chart 26.)

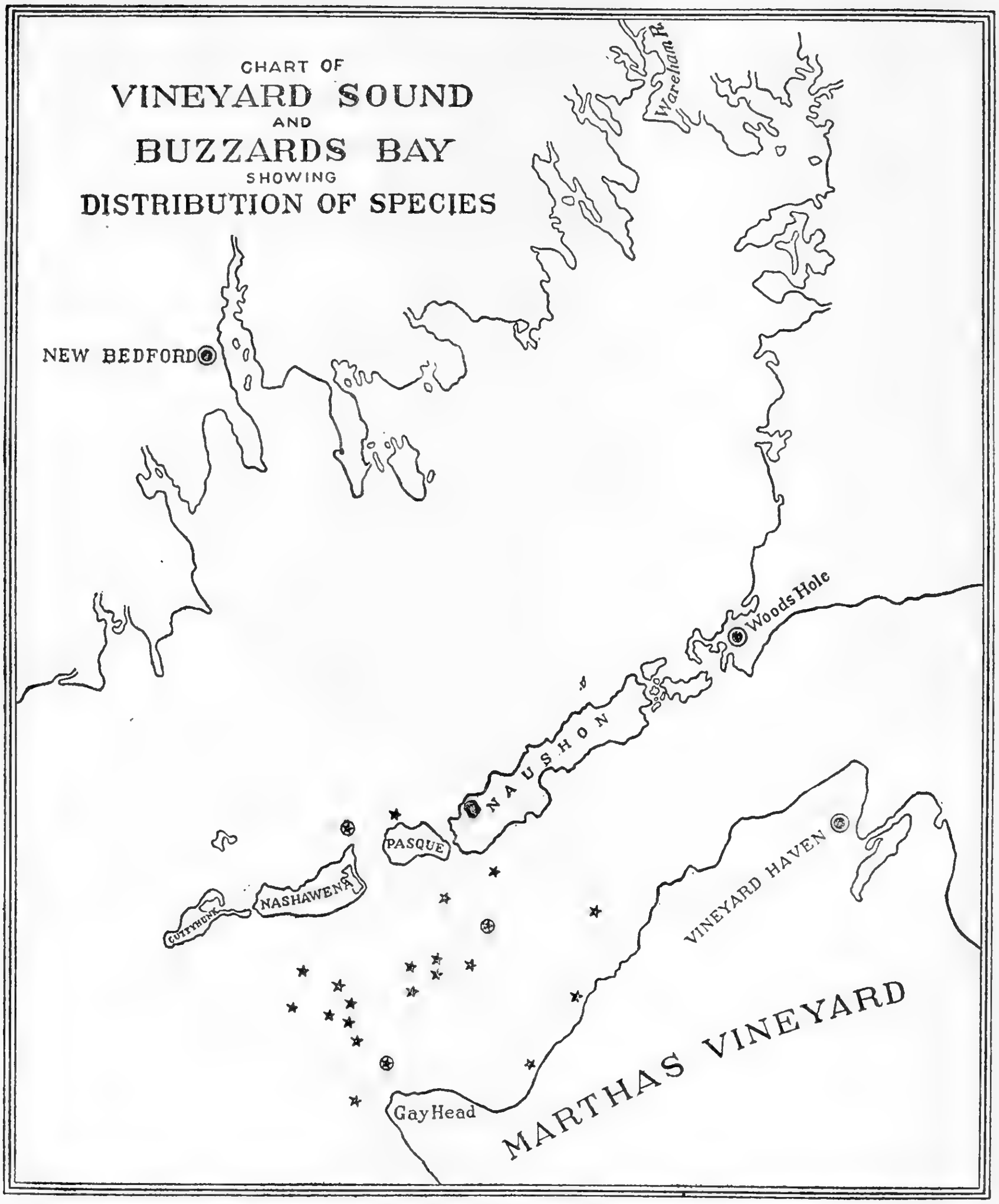


CHART 130.—Crenella glandula. (See explanation of chart 26.)

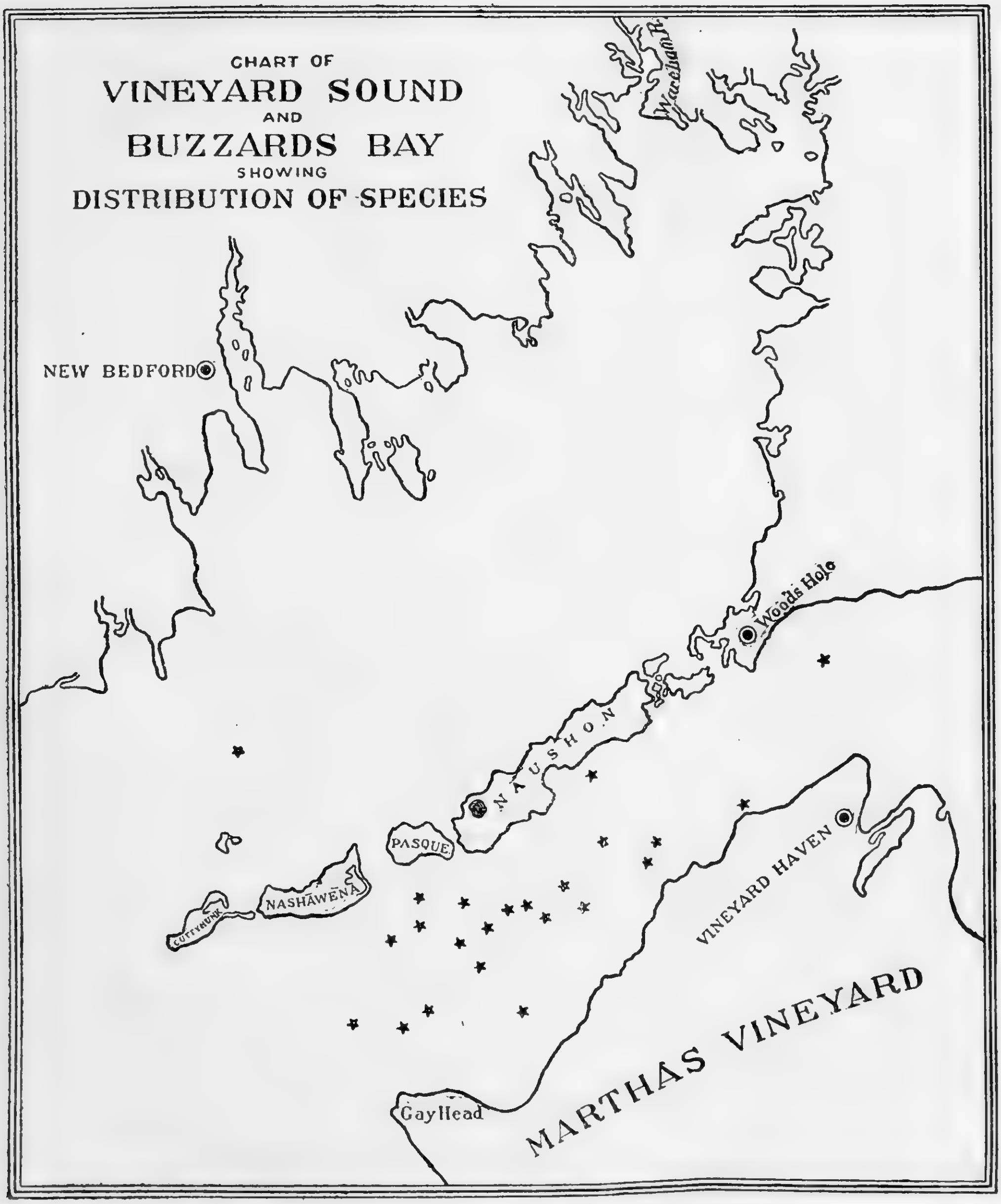


CHART 131.—Arca ponderosa. (See explanation of chart 26.)

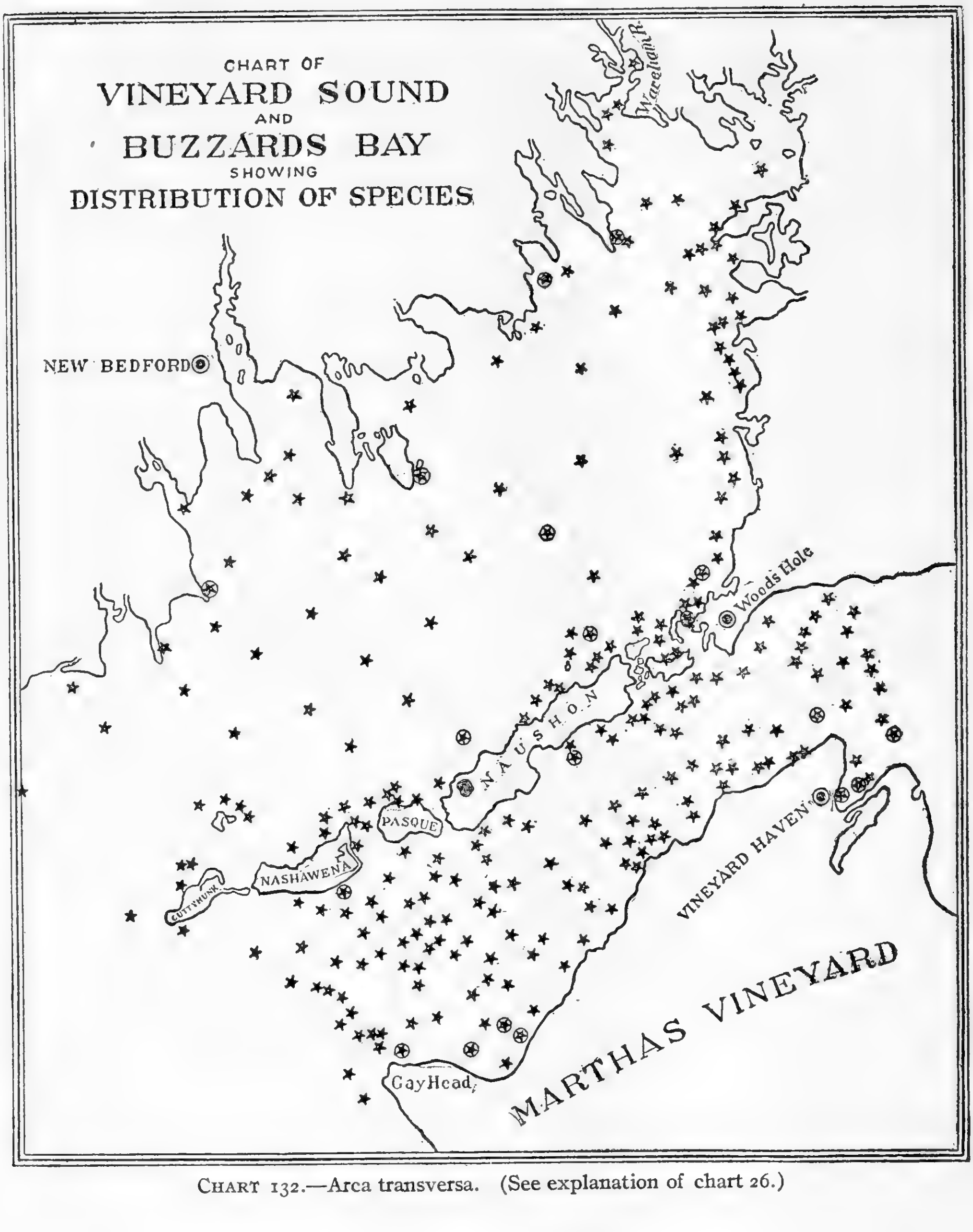


CHART 132.—Arca transversa. (See explanation of chart 26.)

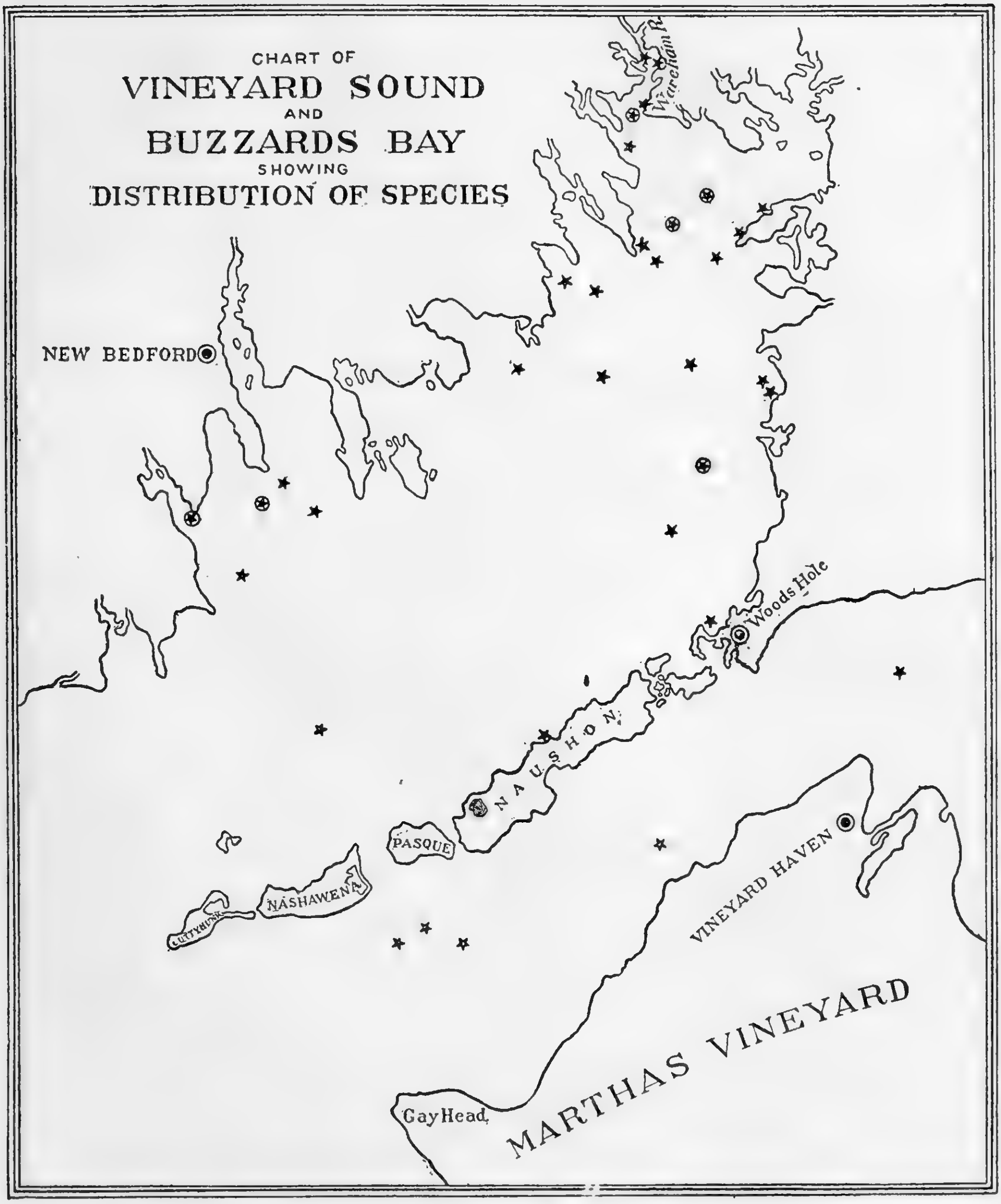


CHART 133.—Arca campechiensis pexata. (See explanation of chart 26.)

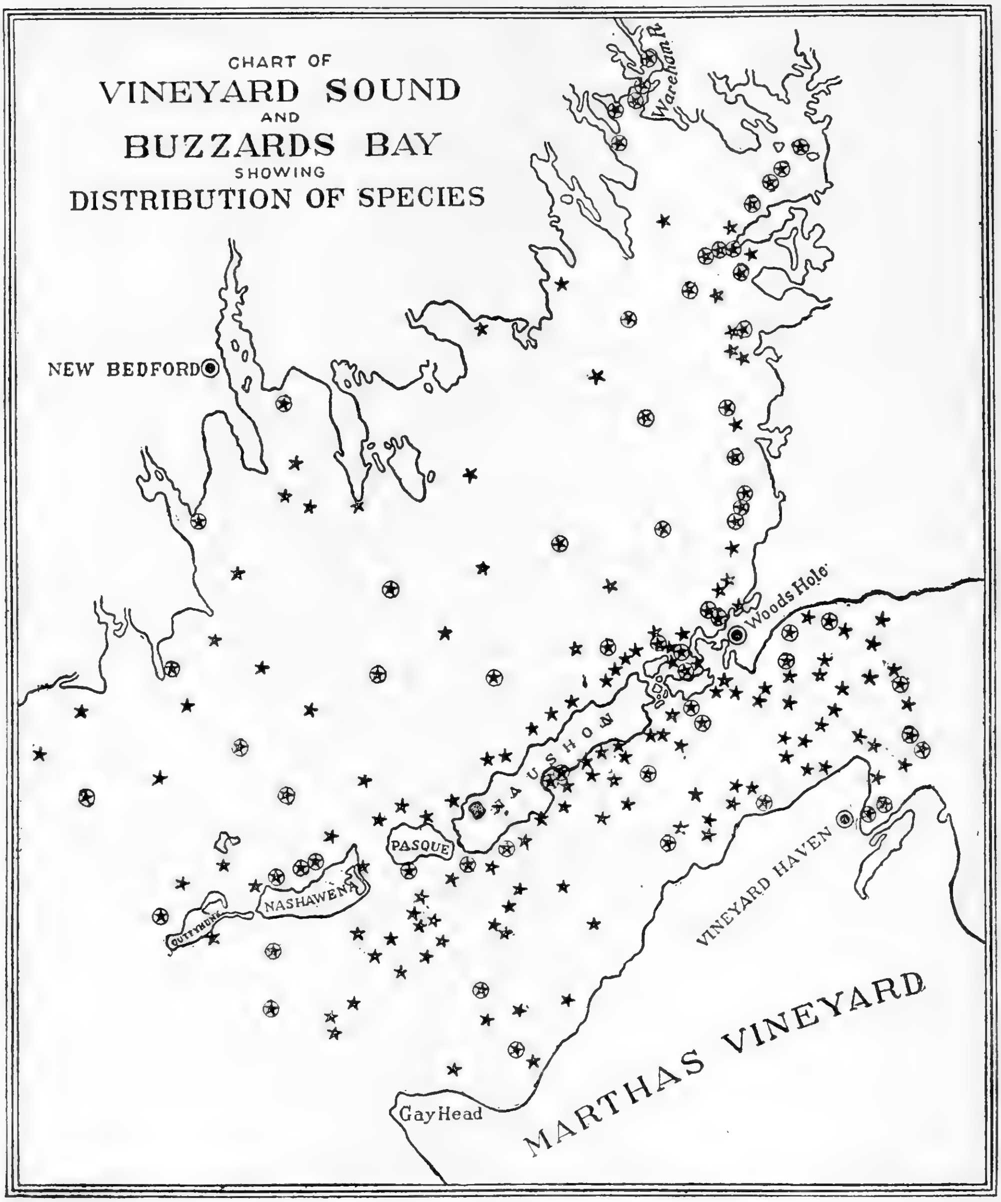


CHART 134.—Nucula proxima. (See explanation of chart 26.)

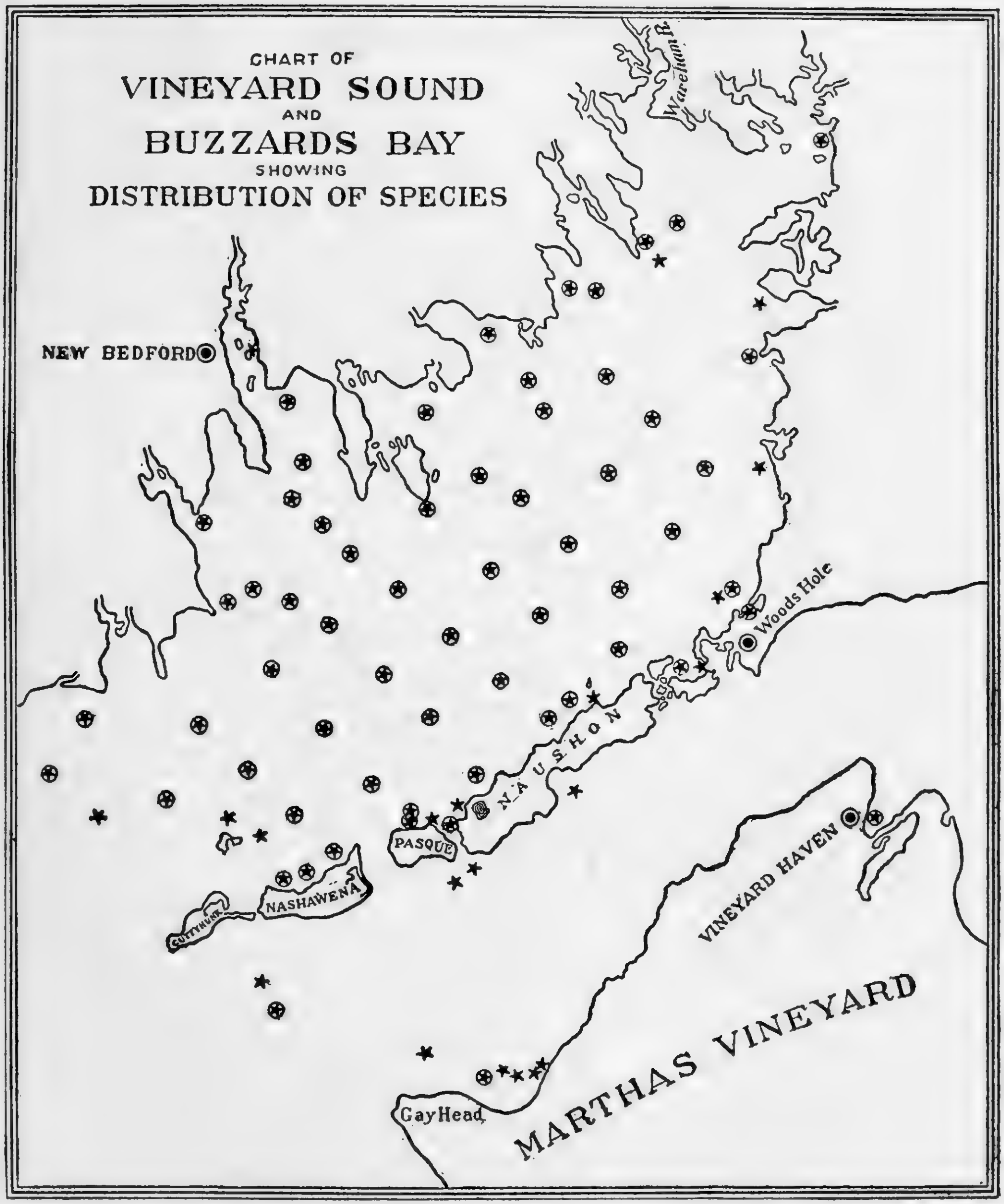


CHART 135.—Yoldia limatula. (See explanation of chart 26.)

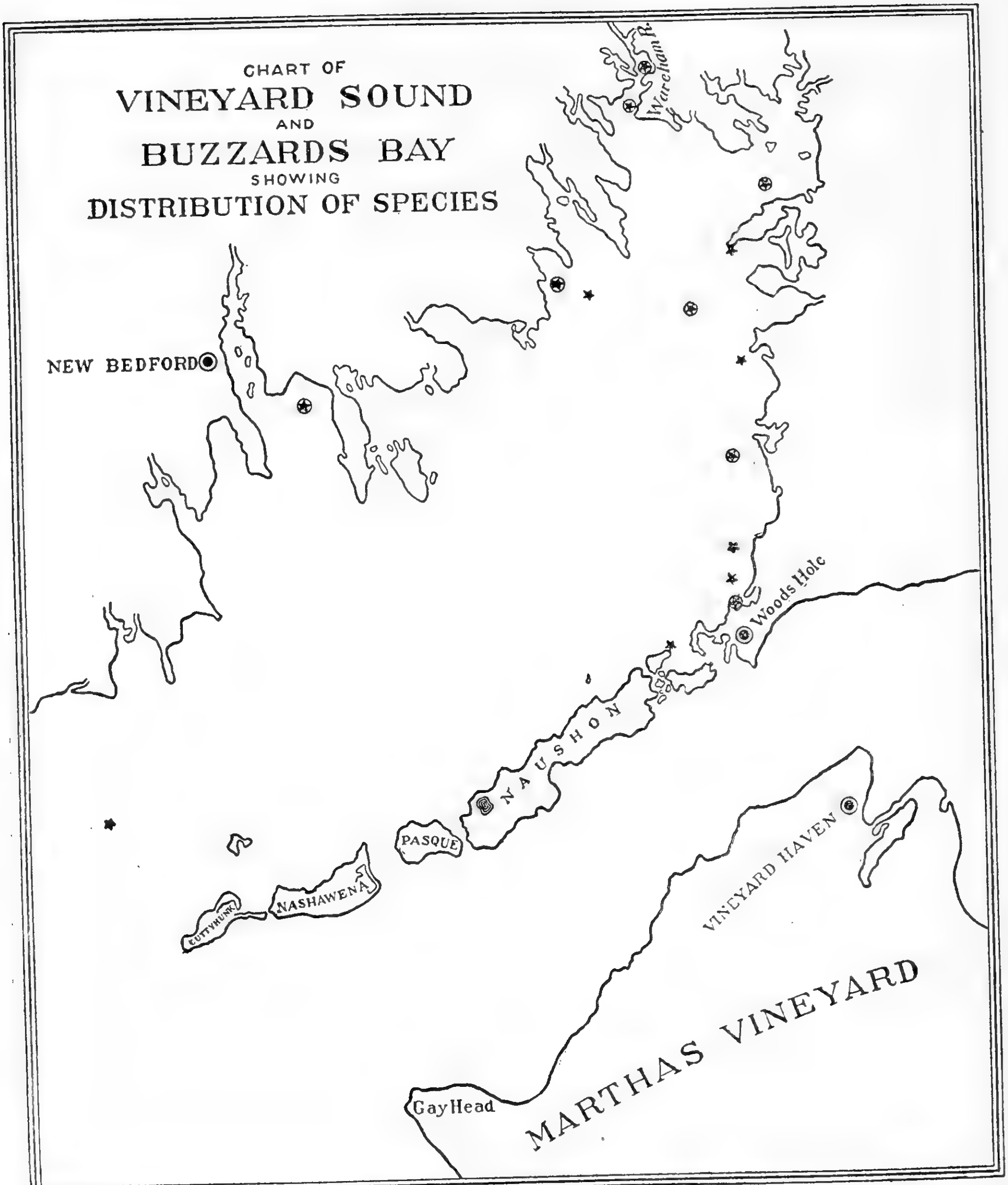


CHART 136.—Solemya velum. (See explanation of chart 26.)

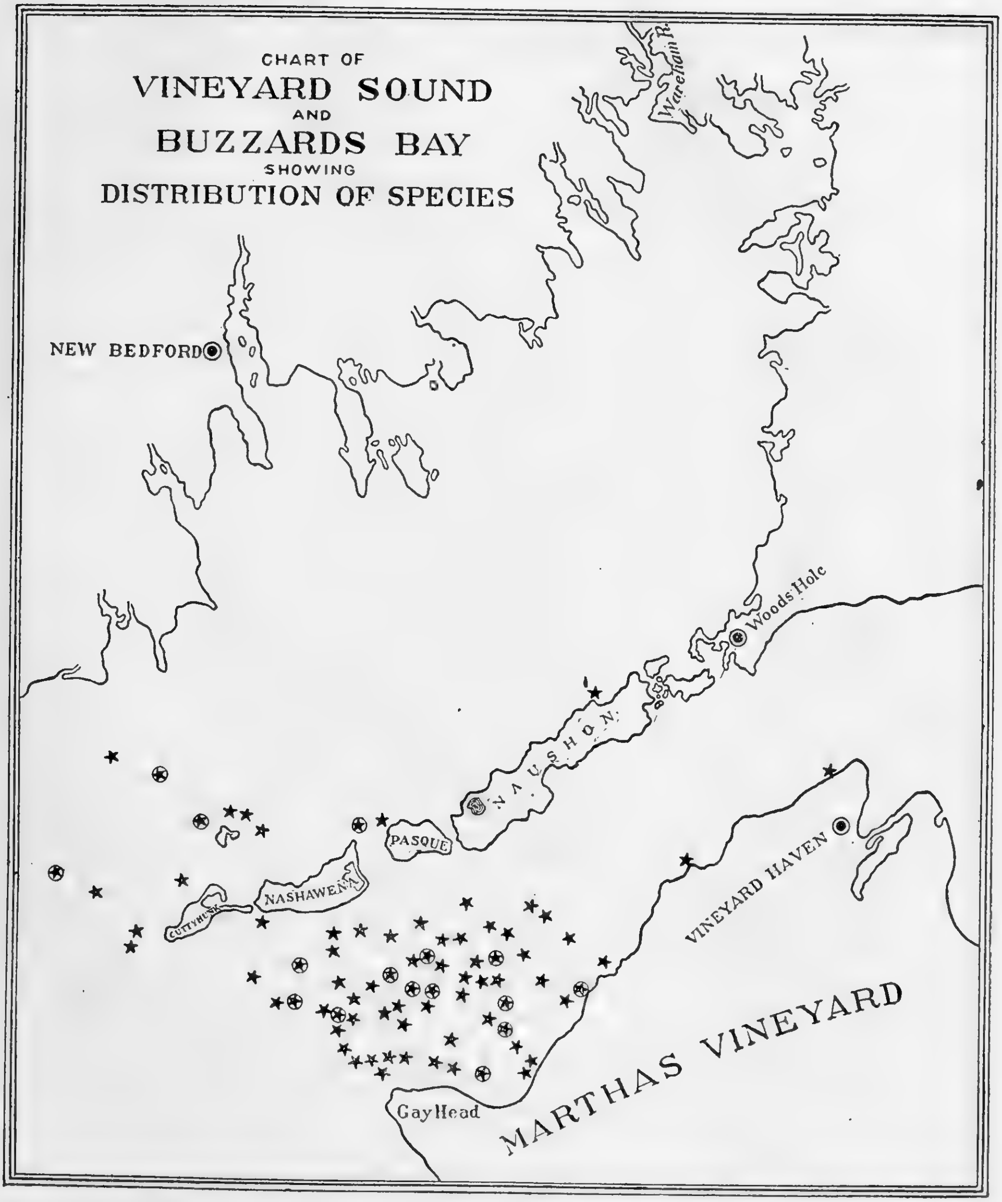


CHART 137.—Venericardia borealis. (See explanation of chart 26.)

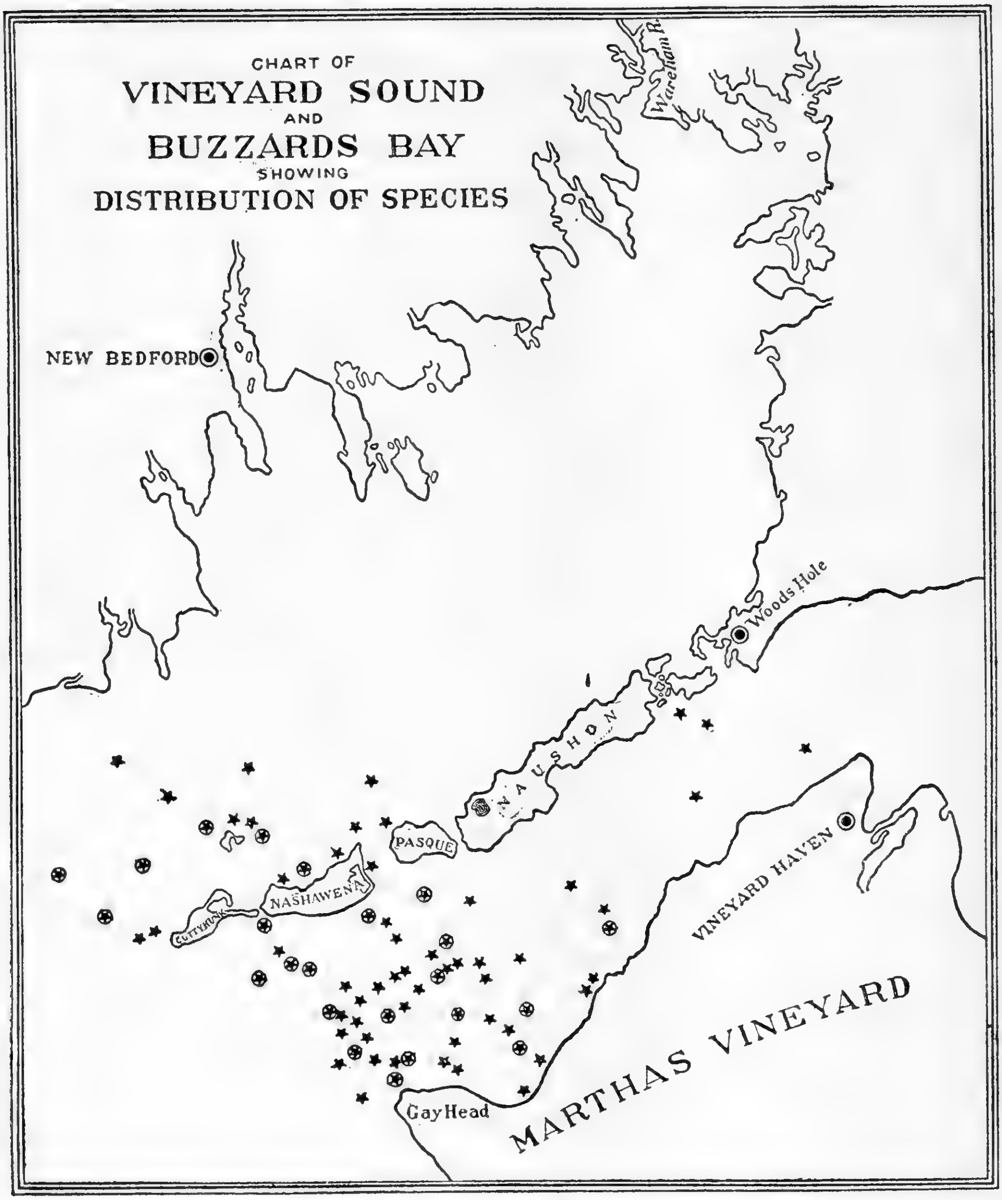


CHART 138.—Astarte undata. (See explanation of chart 26.)

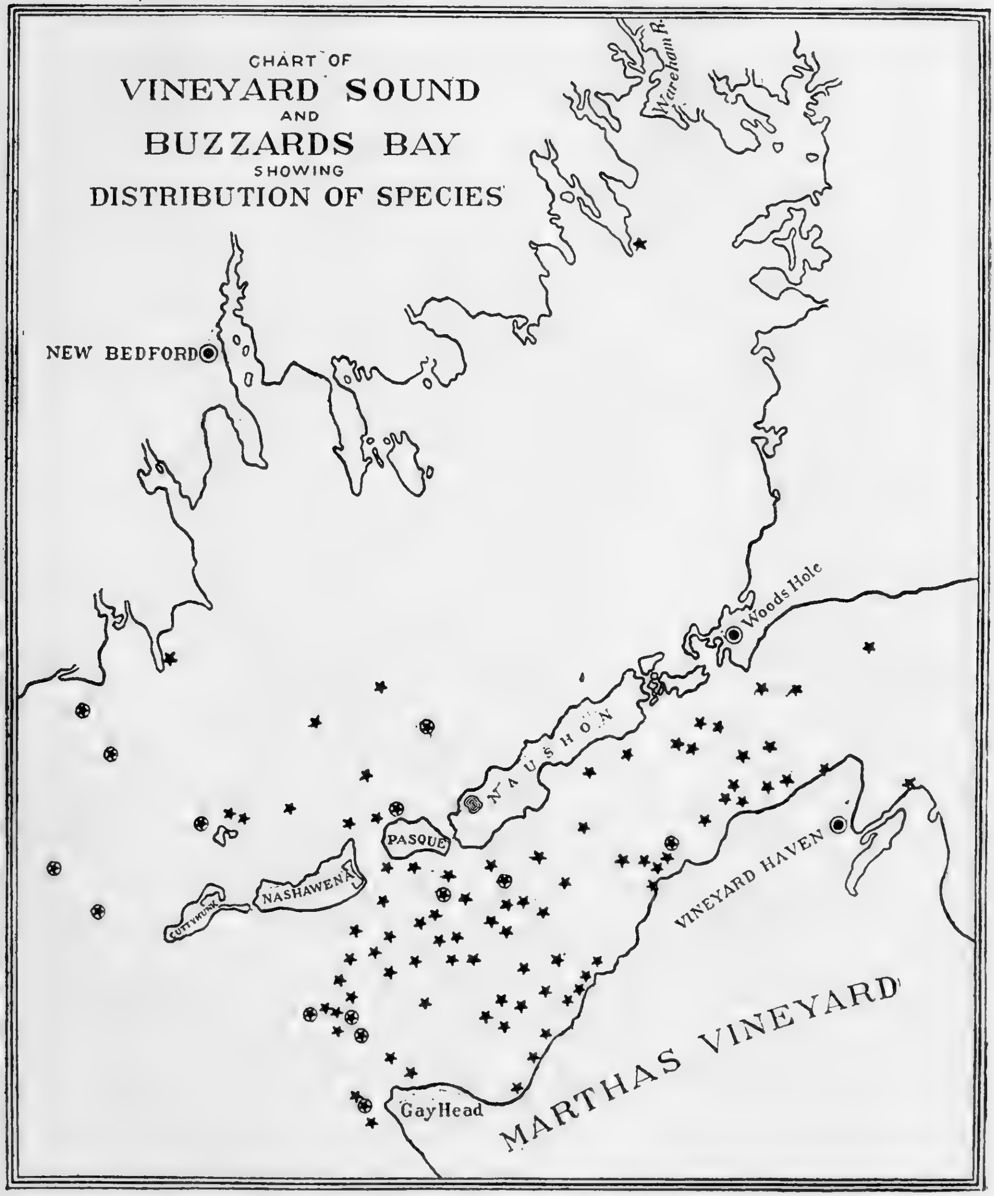


CHART 139.—Astarte castanea. (See explanation of chart 26.)

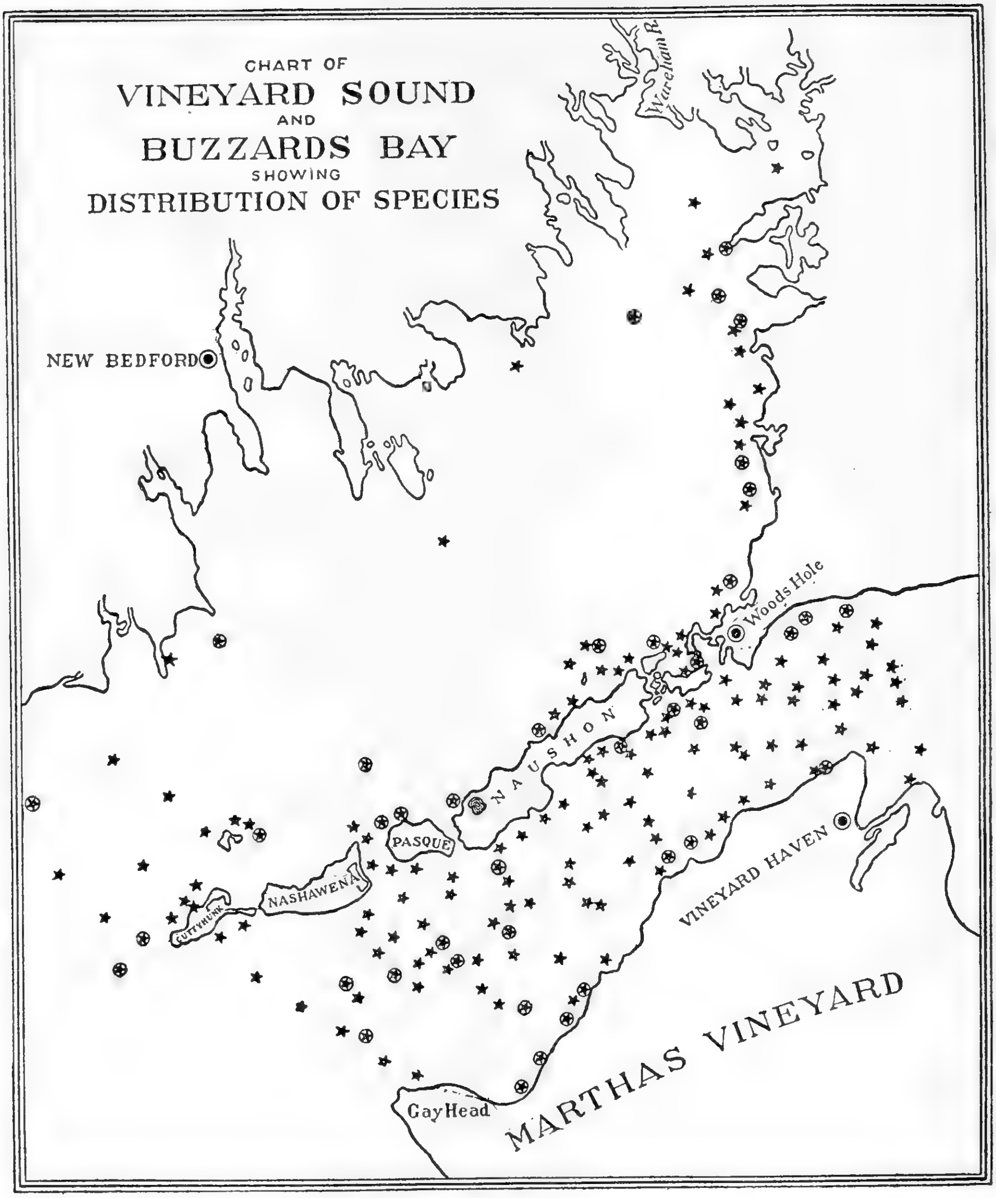


CHART 140.—Crassinella mactracea. (See explanation of chart 26.)

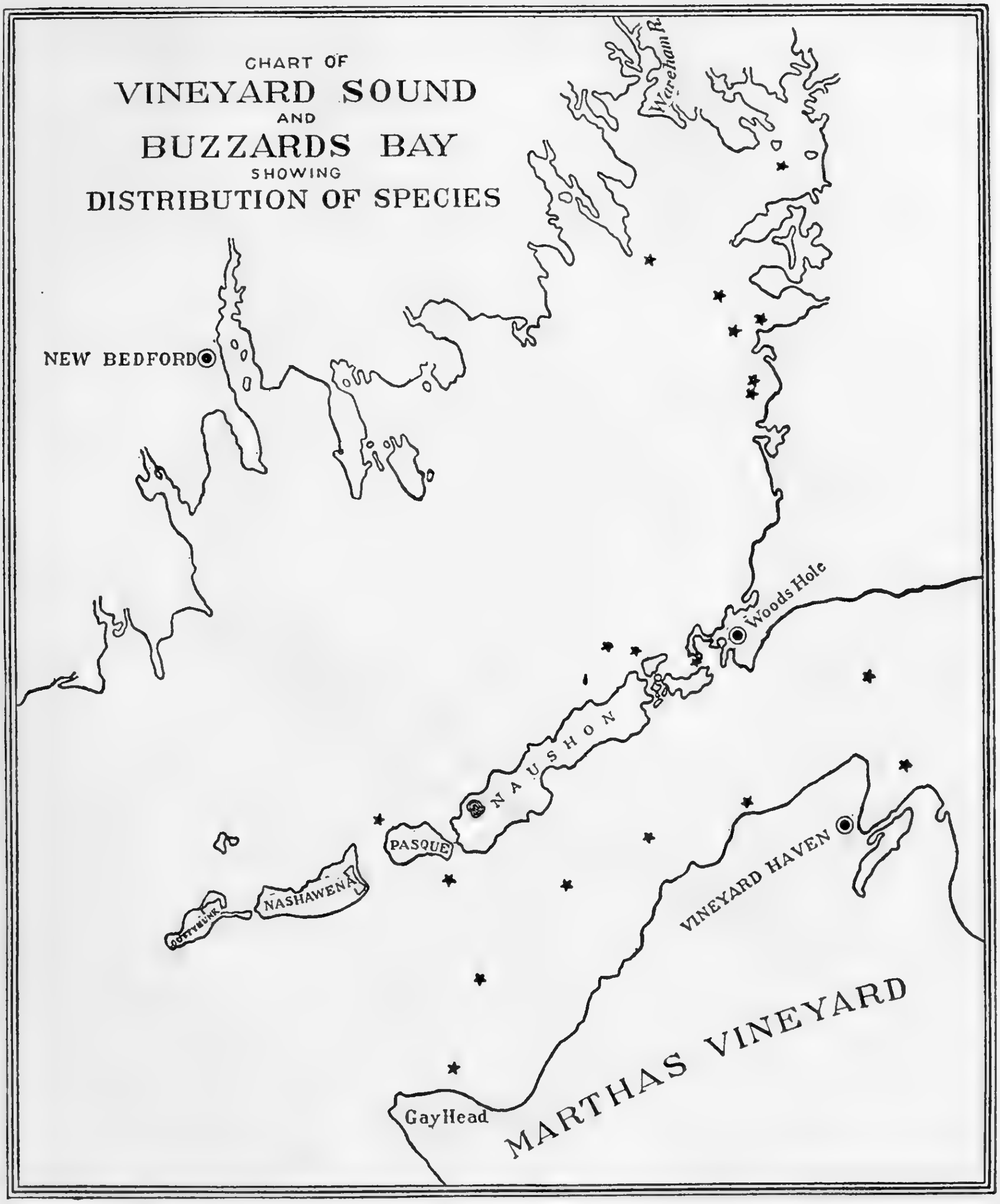


CHART 141.—Divaricella quadrisulcata. (See explanation of chart 26.)

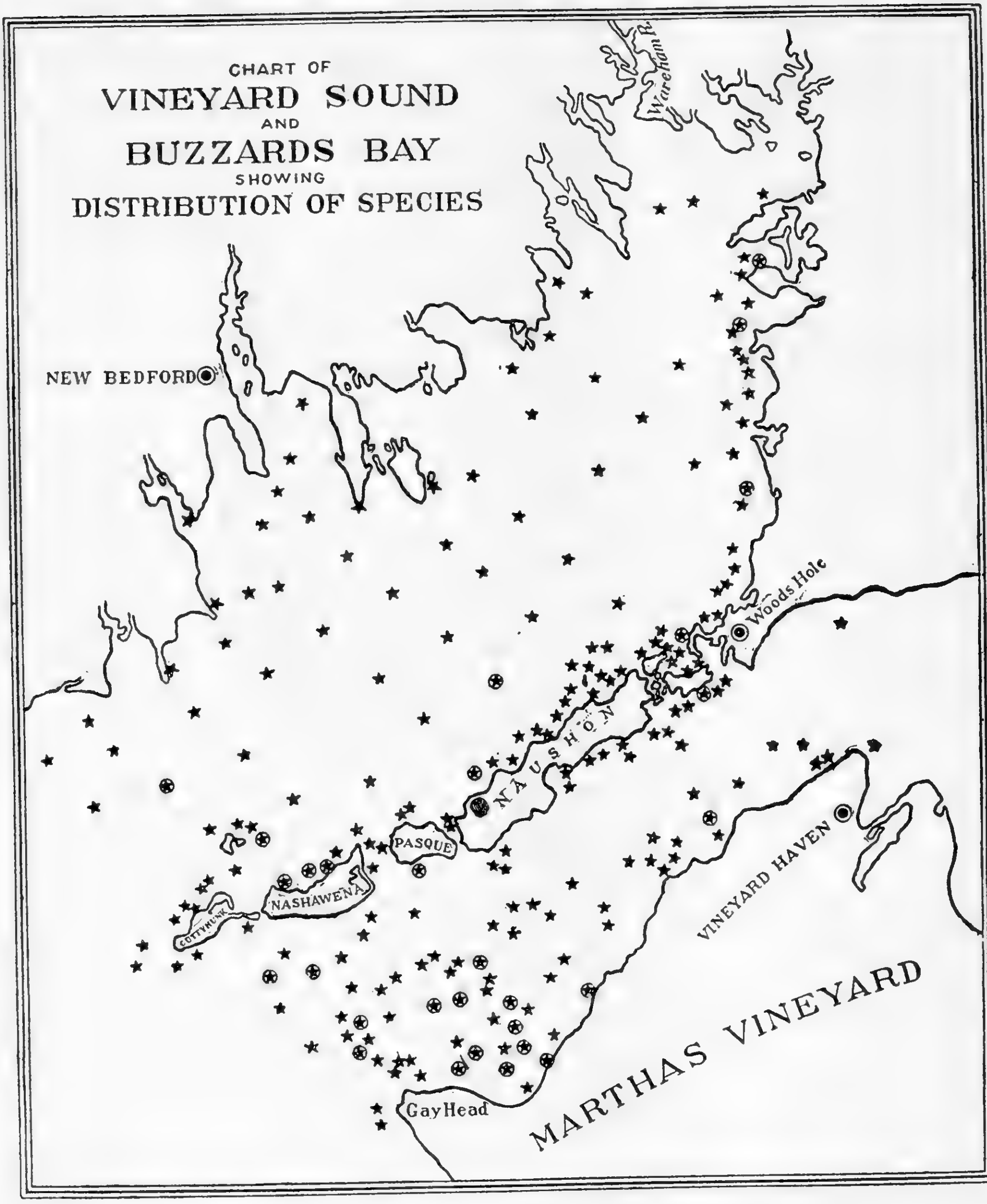


CHART 142.—Cardium pinnulatum. (See explanation of chart 26.)

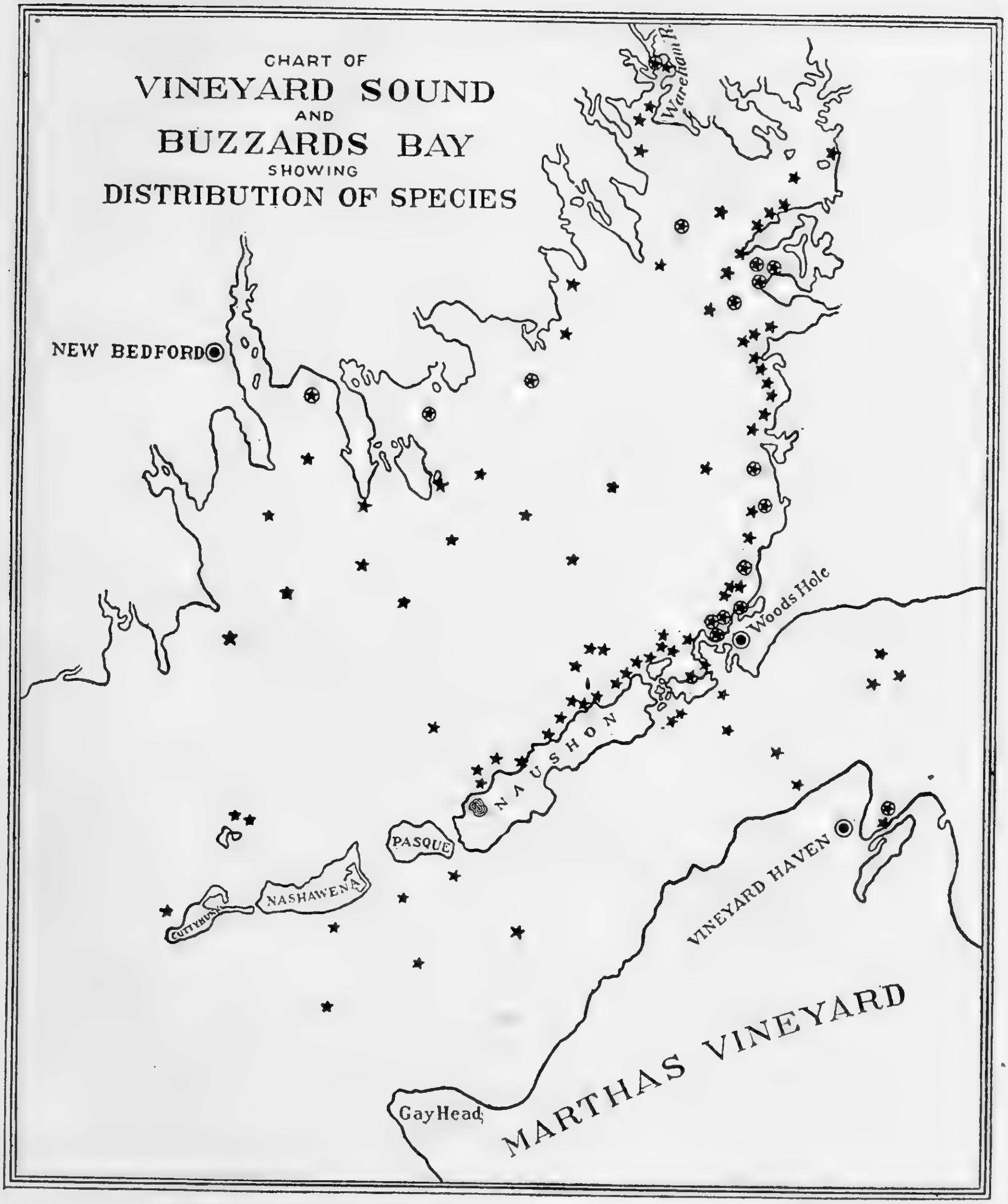


CHART 143.—Lævicardium mortoni. (See explanation of chart 26.)

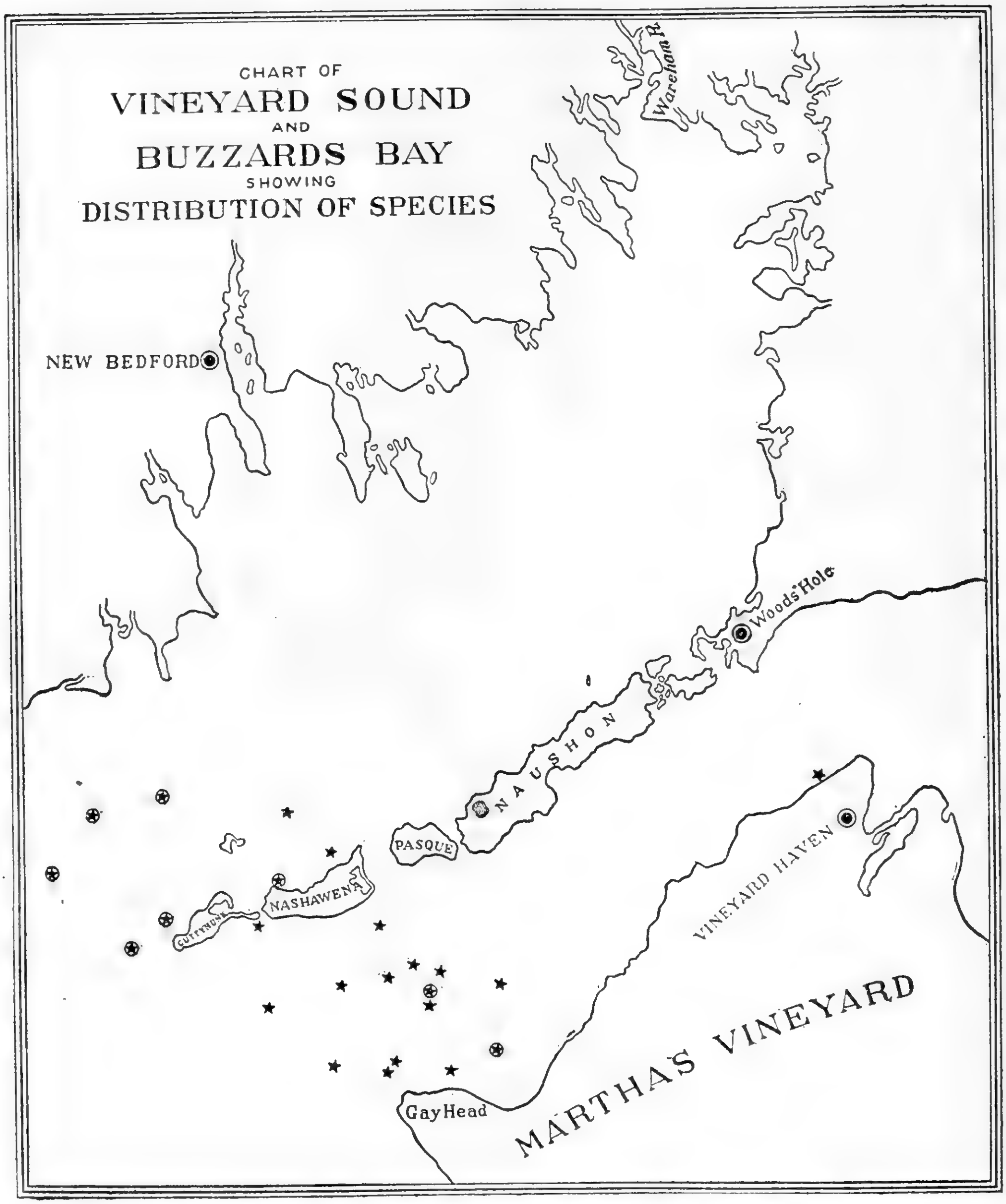


CHART 144.—Cyclas islandica. (See explanation of chart 26.)

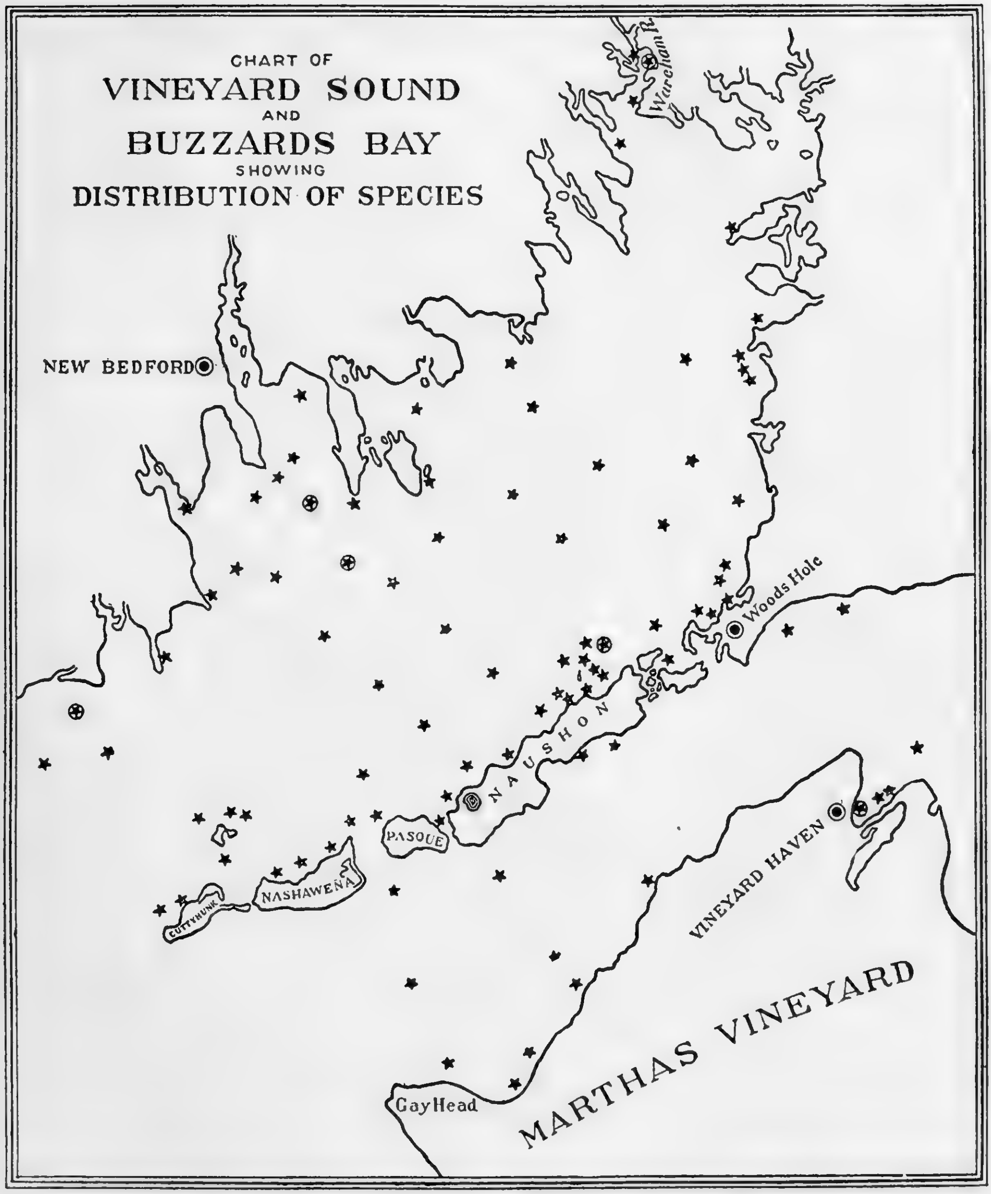


CHART 145.—Venus mercenaria. (See explanation of chart 26.)

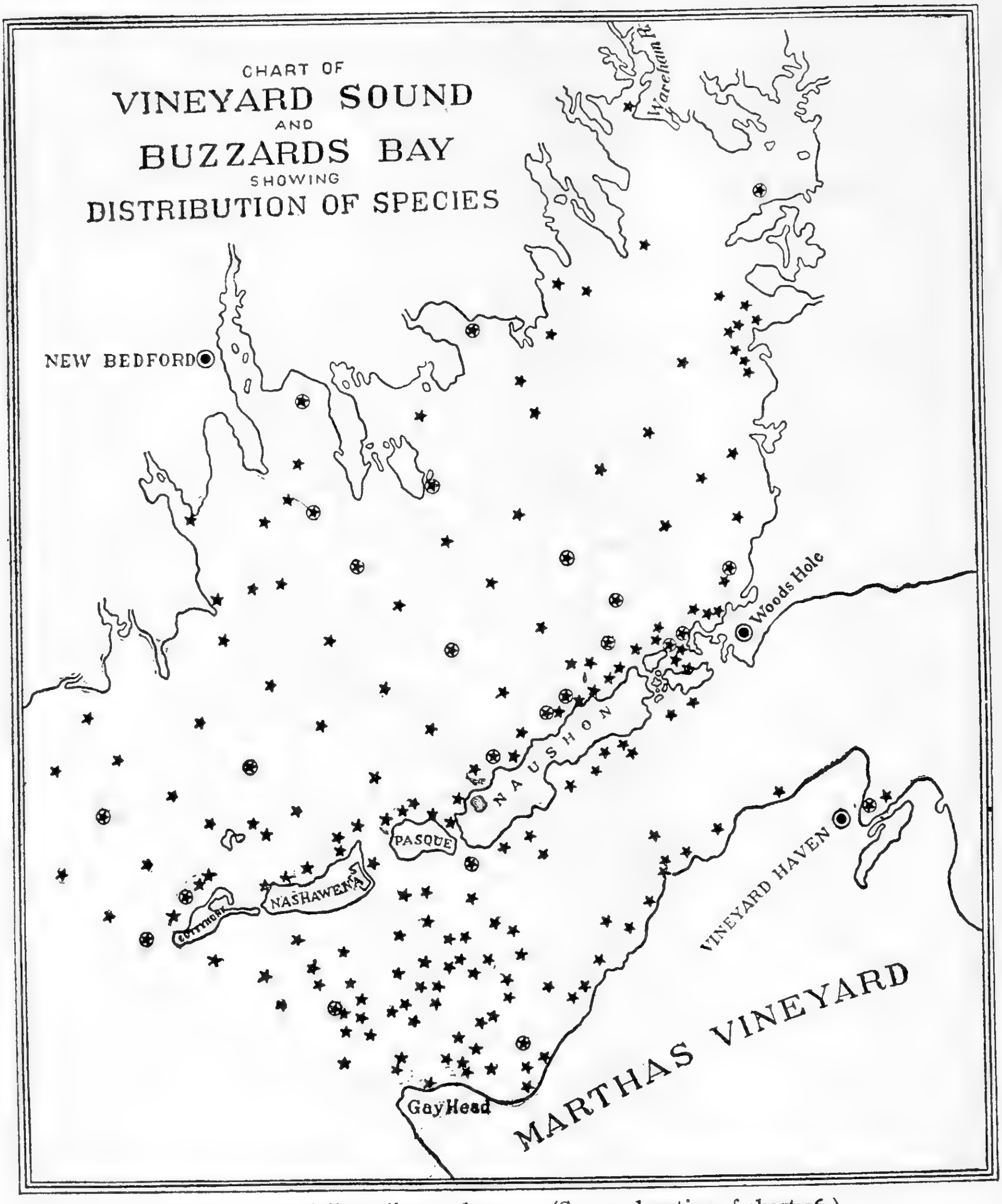


CHART 146.—Callocardia morrhuana. (See explanation of chart 26.)

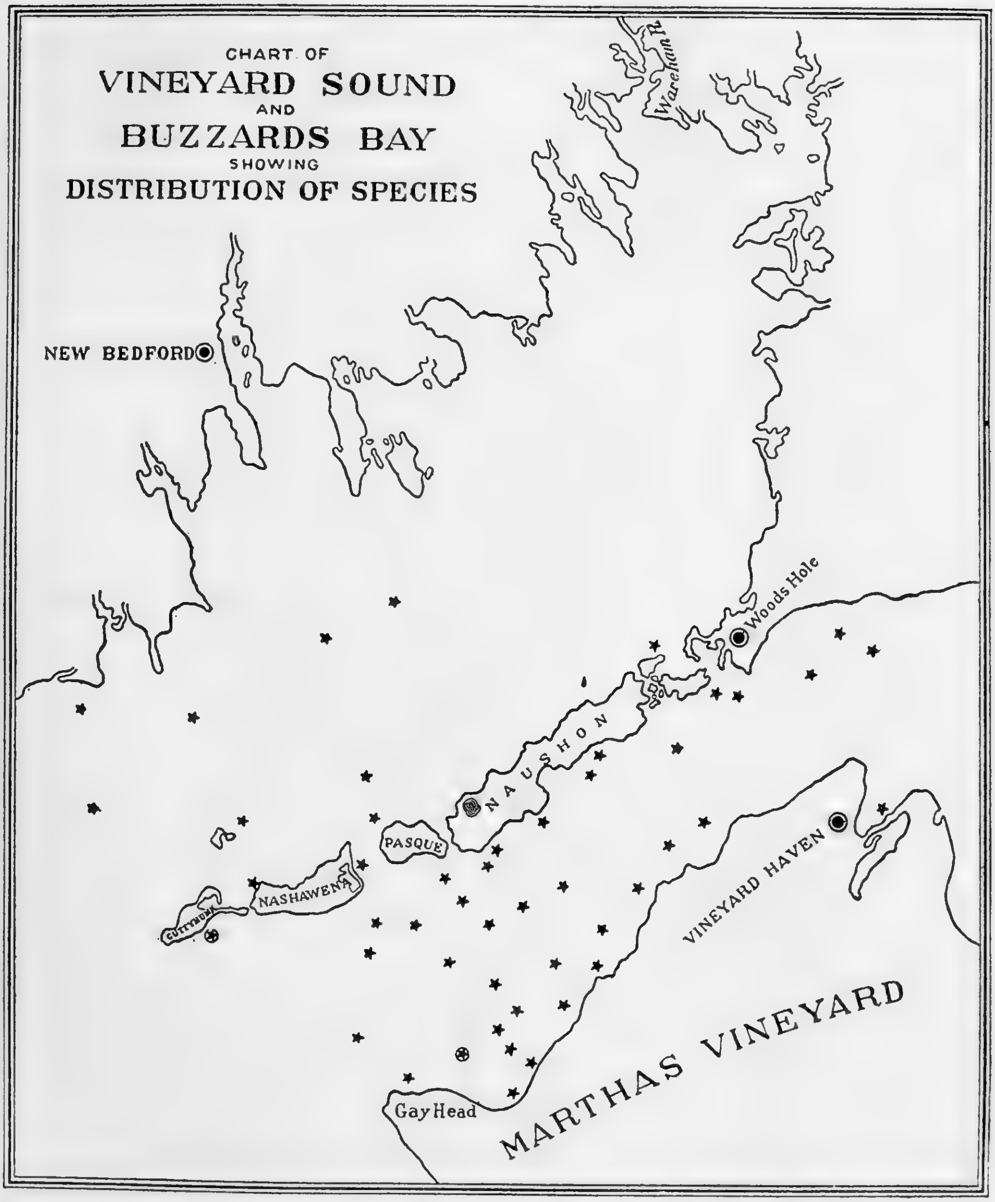


CHART 147.—Petricola pholadiformis. (See explanation of chart 26.)

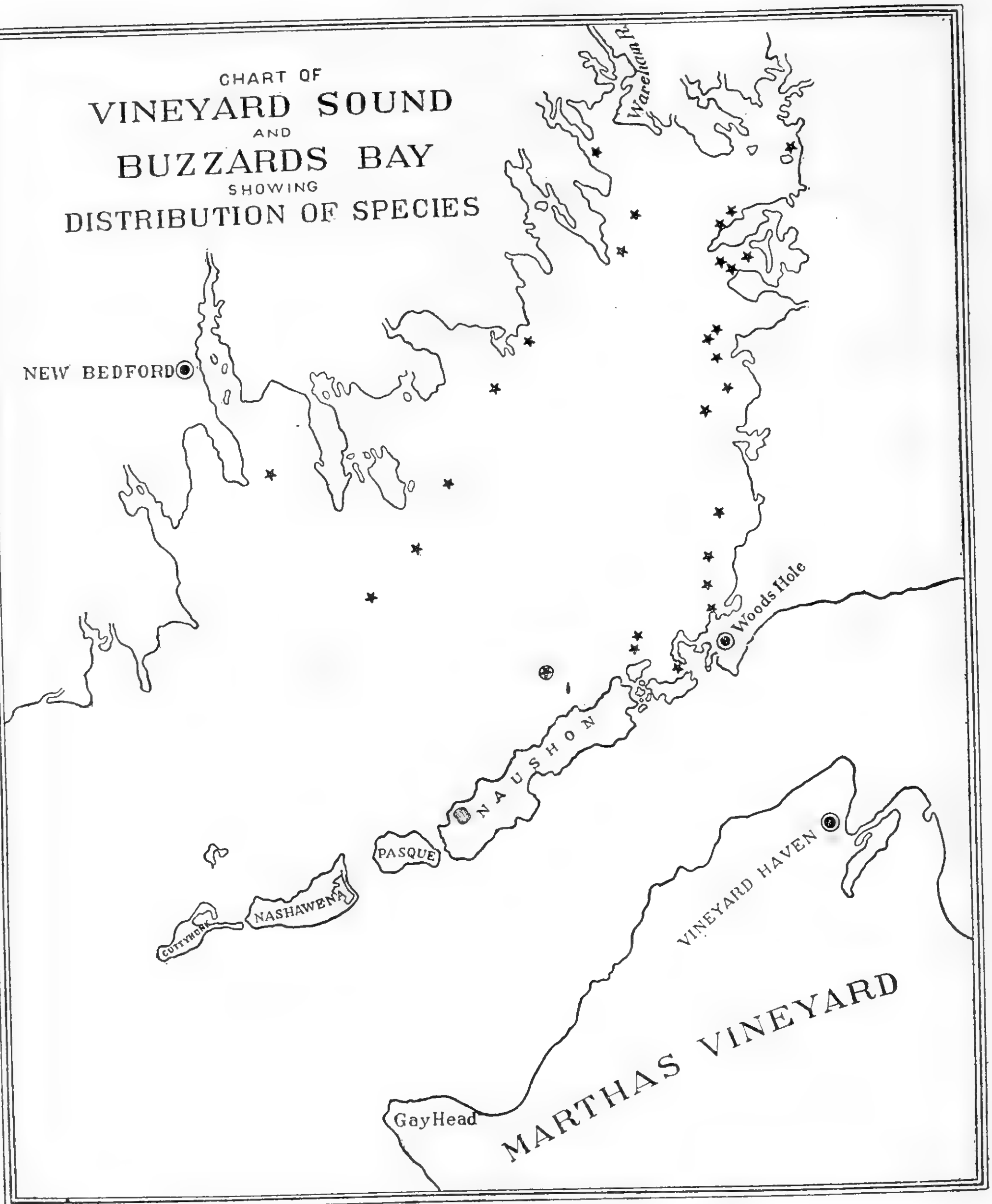


CHART 148.—Tagelus gibbus. (See explanation of chart 26.)

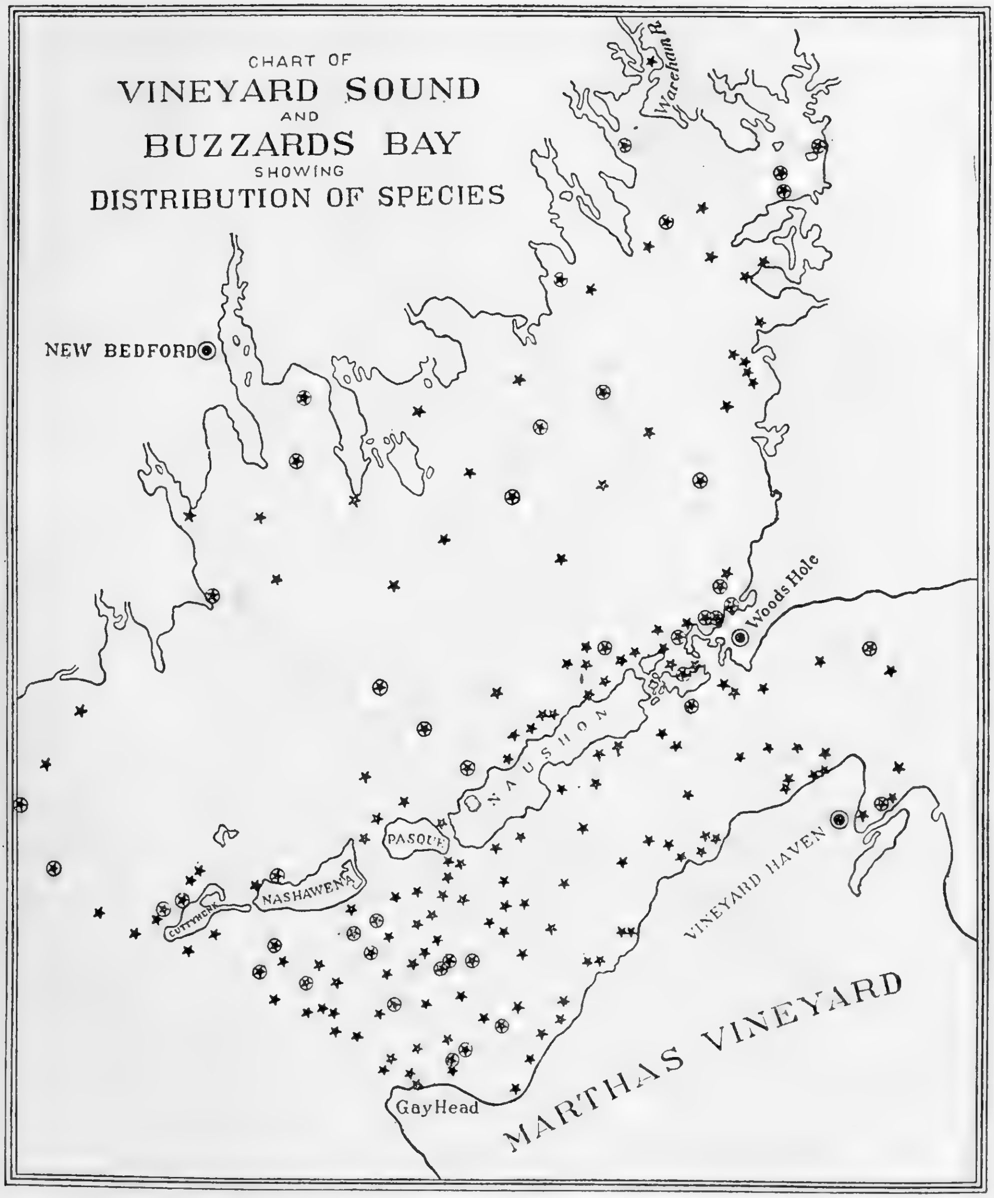


CHART 149.—Tellina tenera. (See explanation of chart 26.)

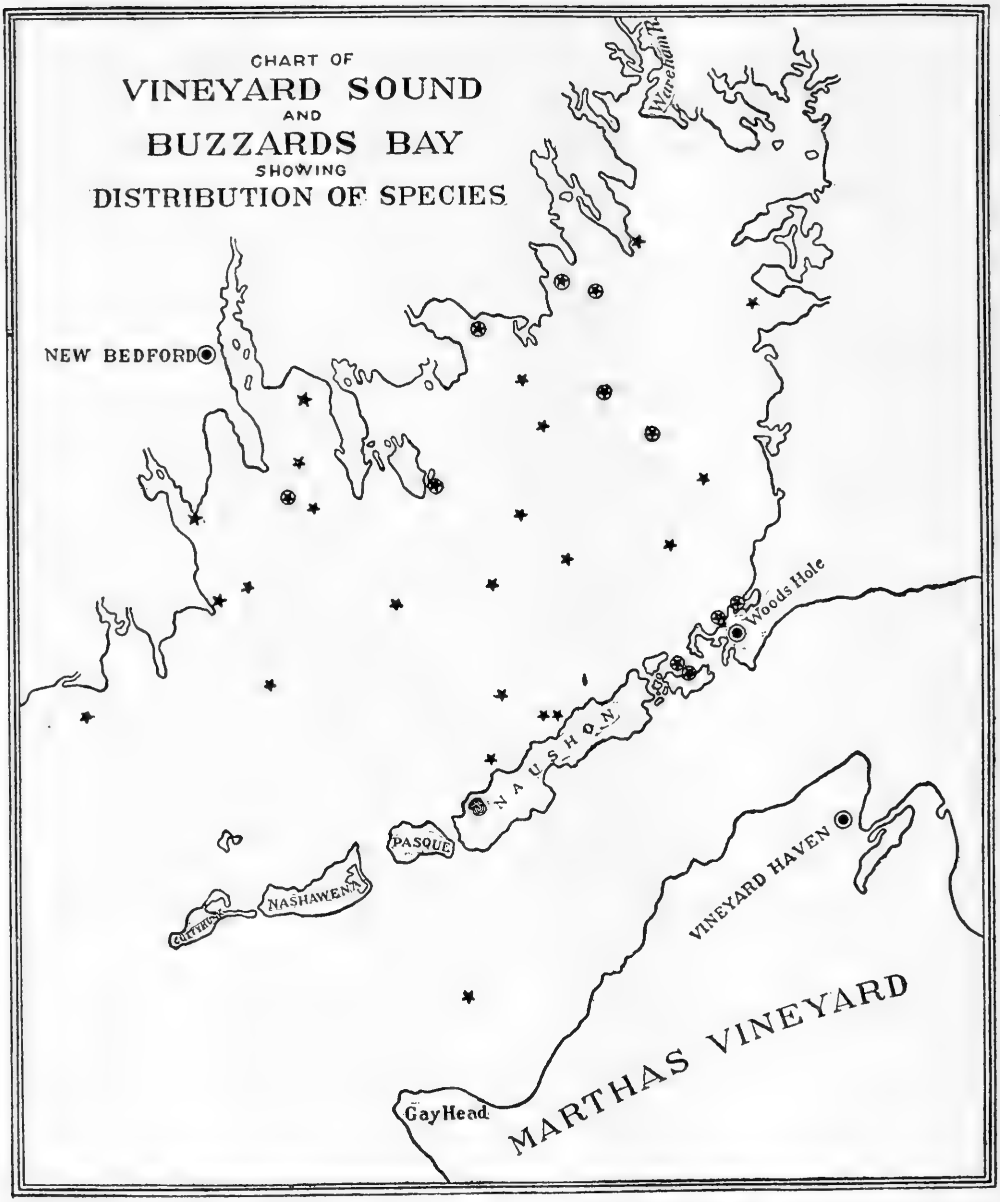


CHART 150.—Macoma tenta. (See explanation of chart 26.)

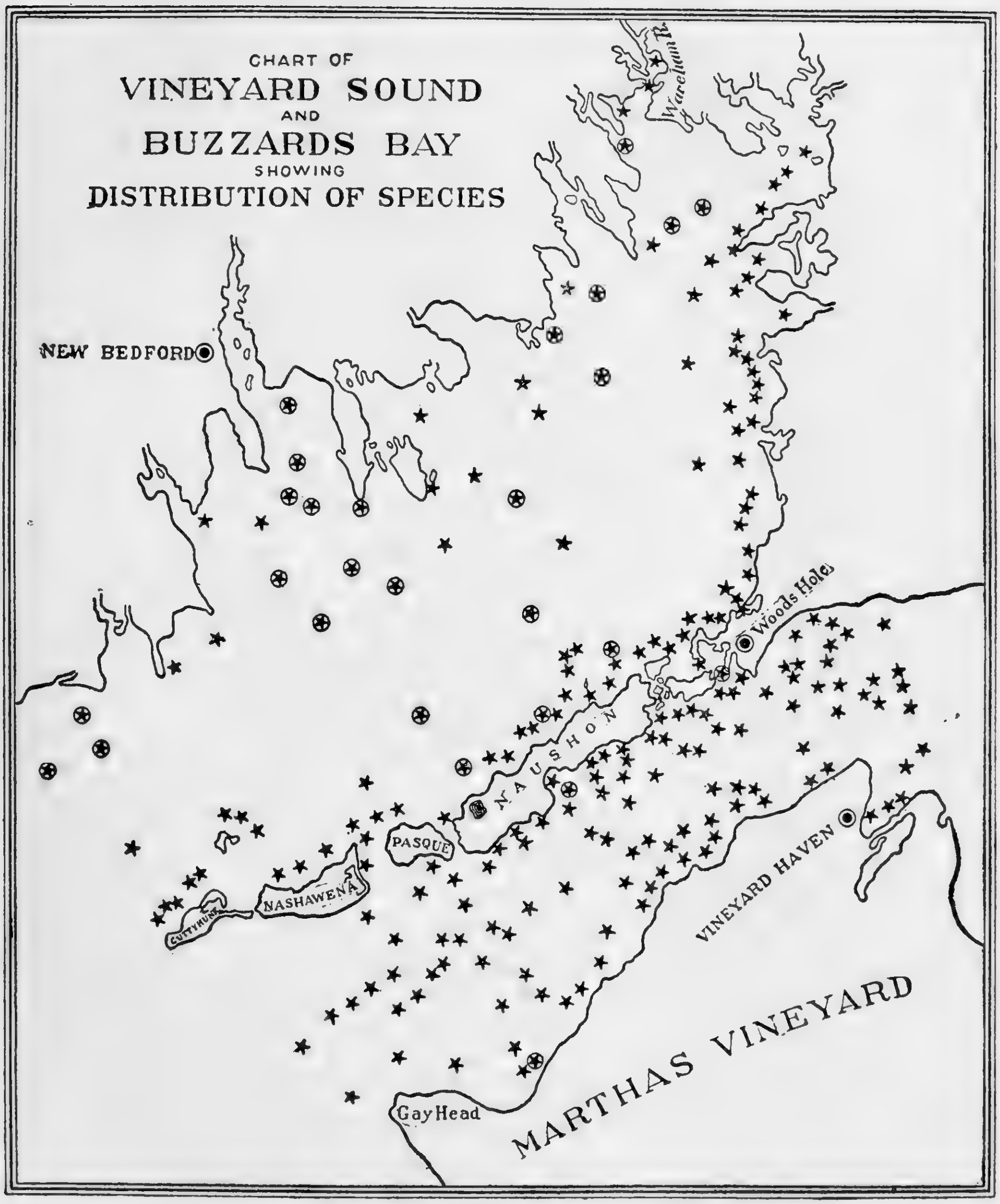


CHART 151.—Ensis directus. (See explanation of chart 26.)

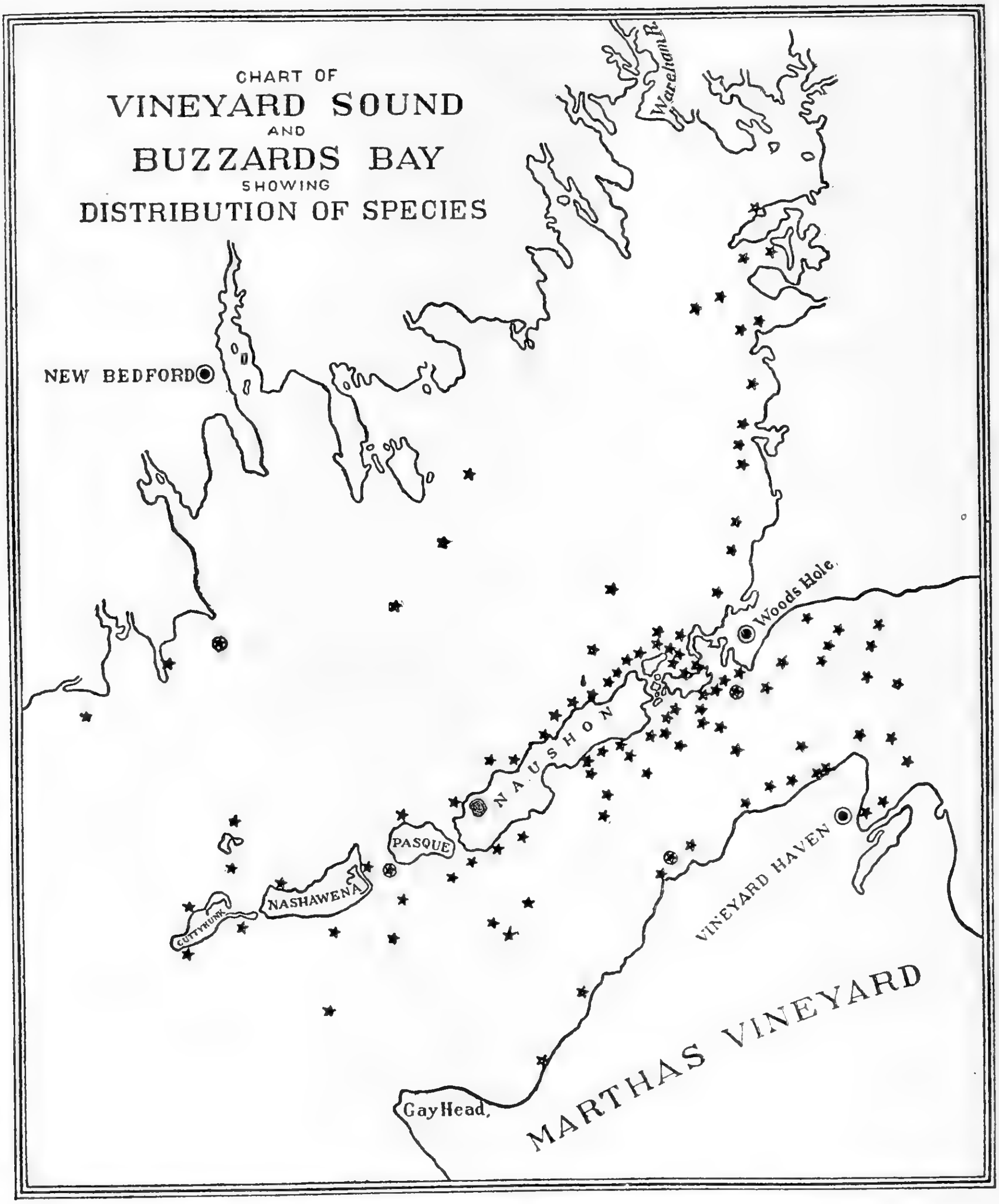


CHART 152.—Cumingia tellinoides. (See explanation of chart 26.)

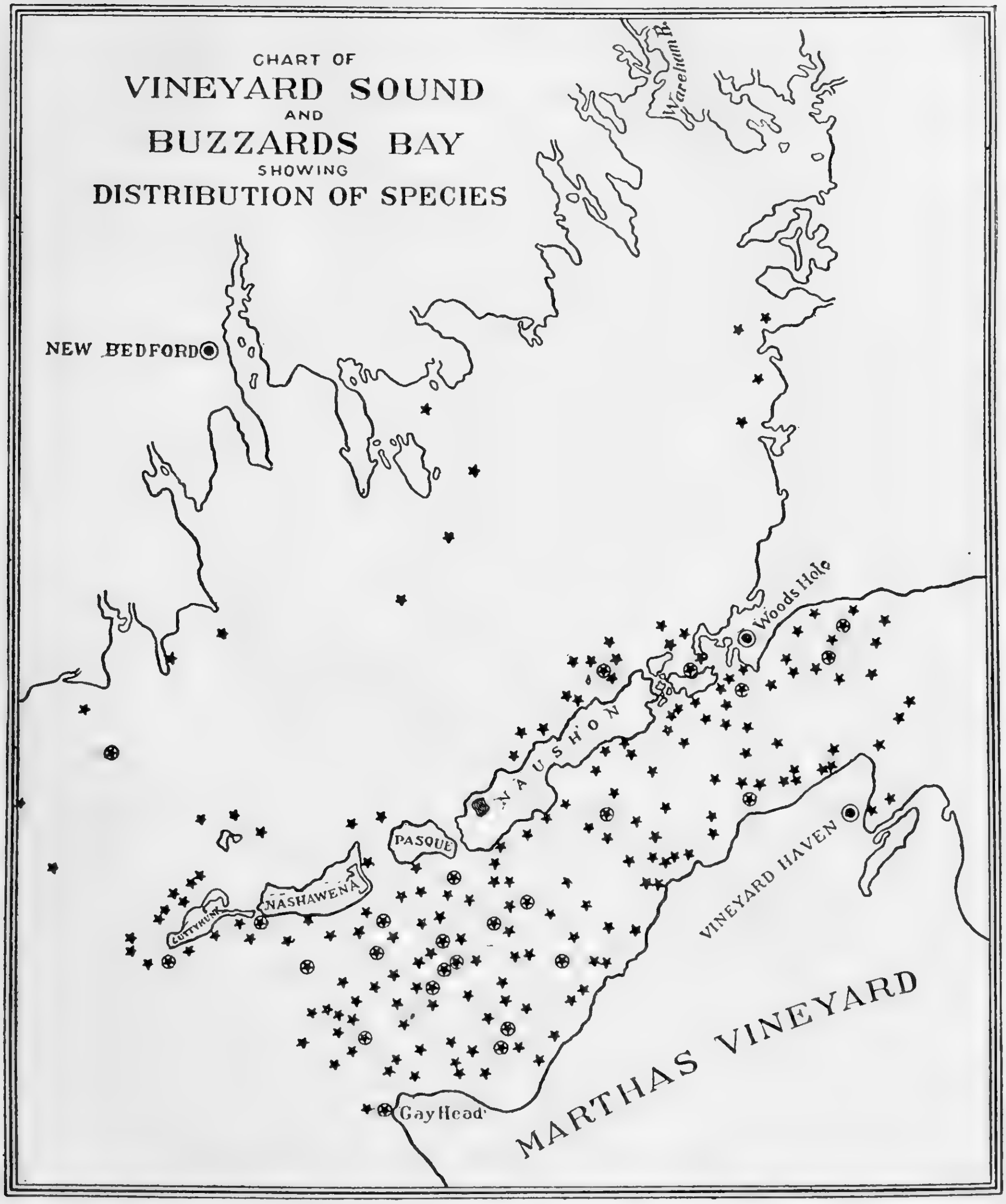


CHART 153.—Spisula solidissima. (See explanation of chart 26.)

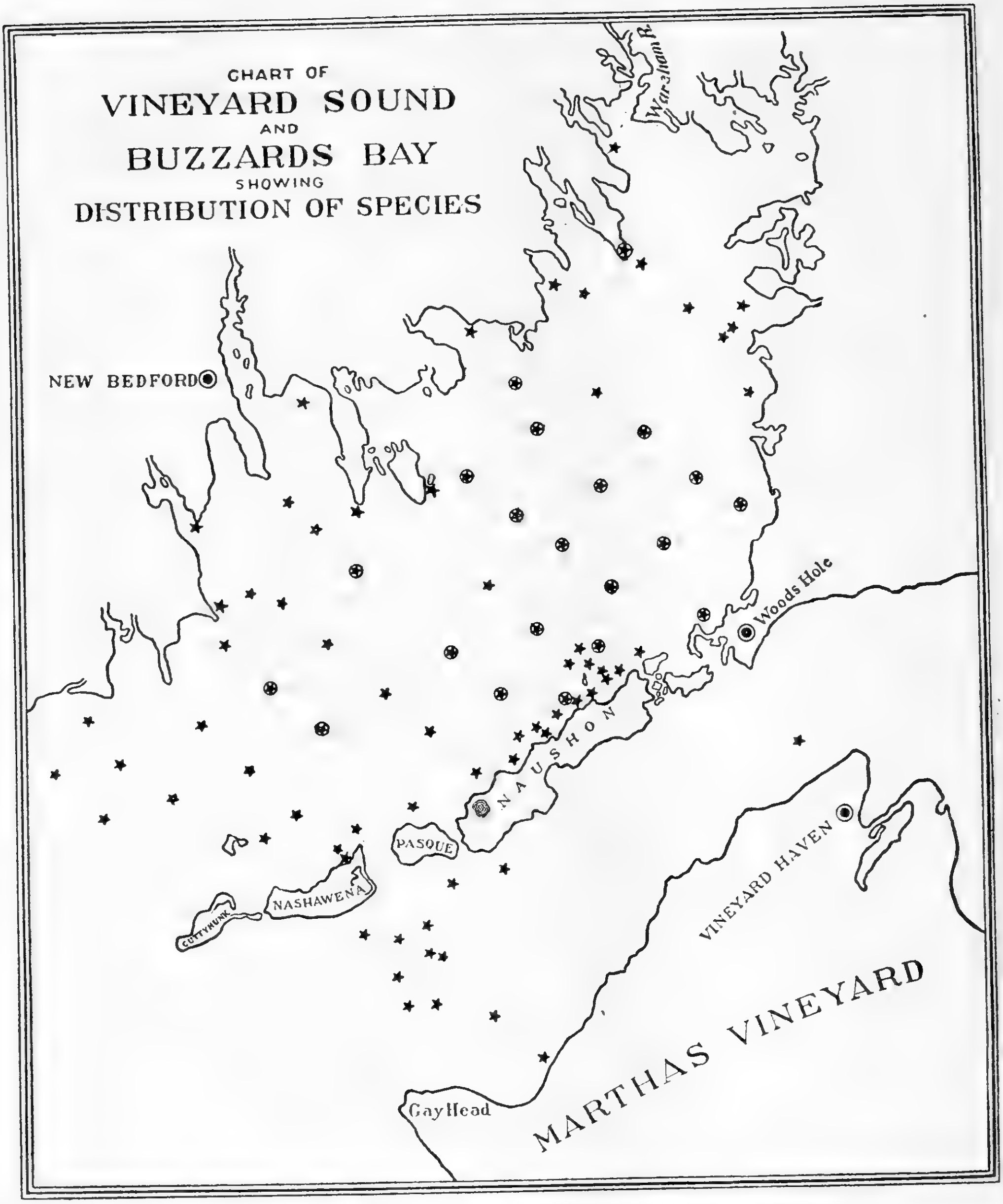


CHART 154.—Mulinia lateralis. (See explanation of chart 26.)

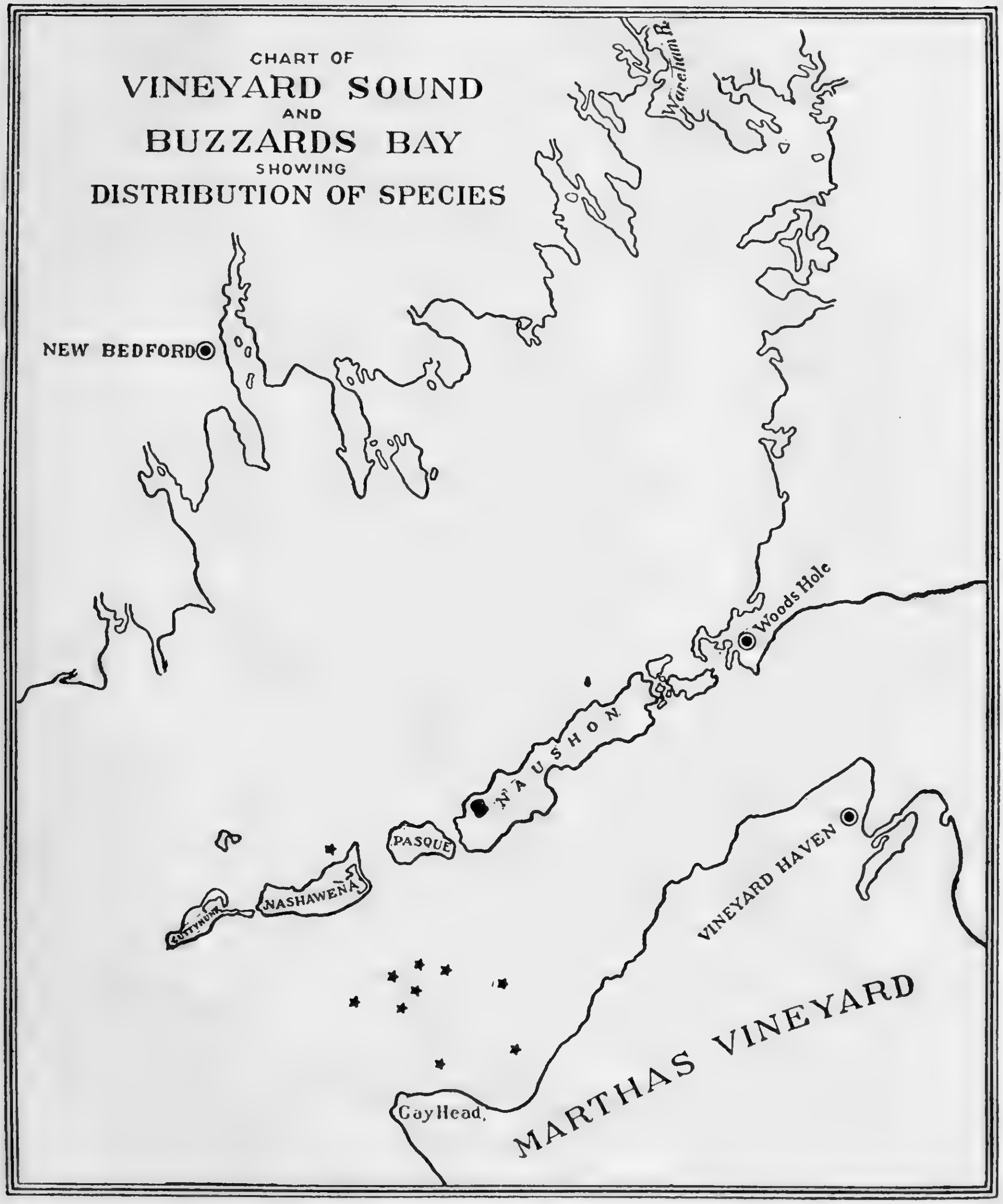


CHART 155.—Thracia conradi. (See explanation of chart 26.)

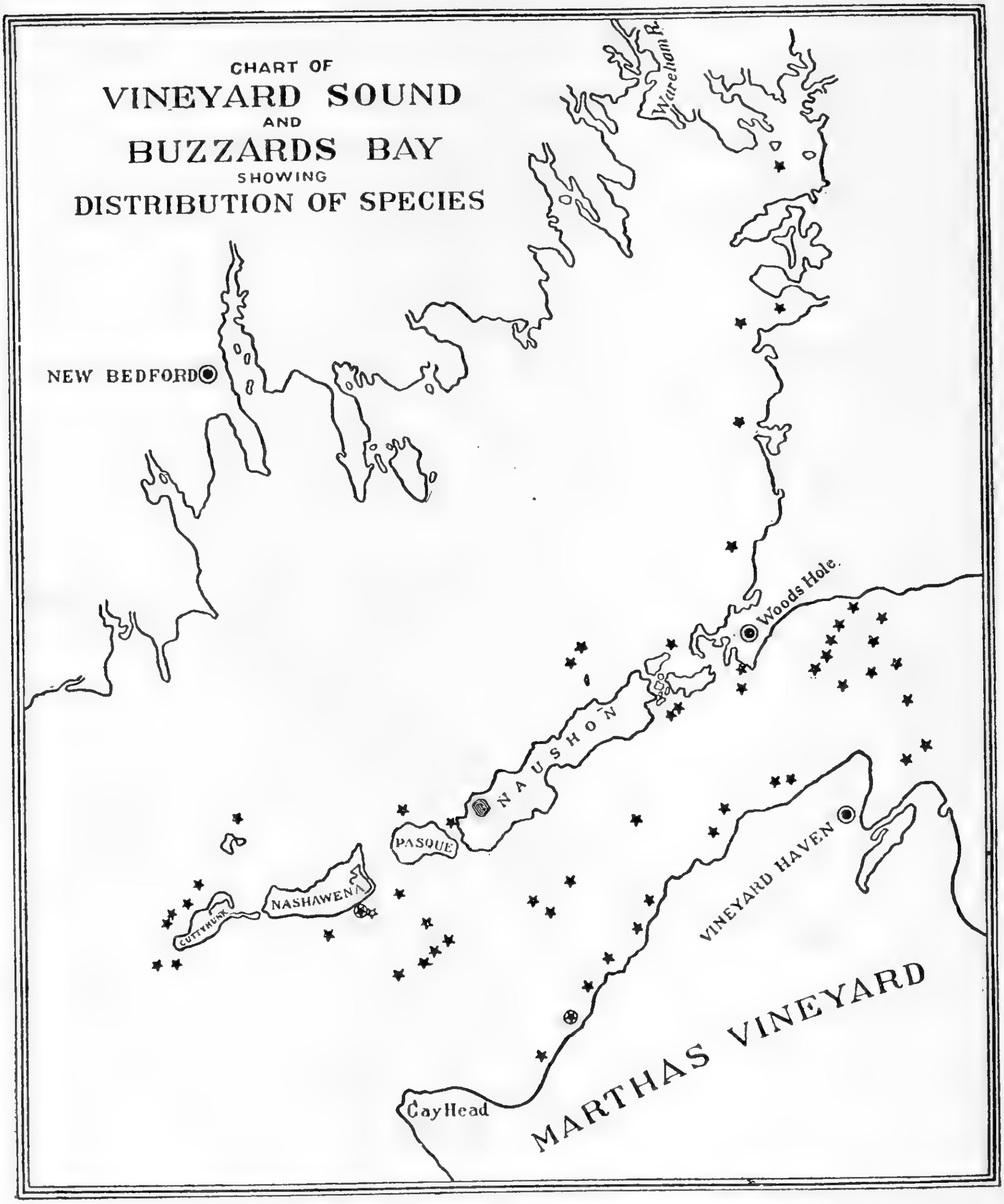


CHART 156.—Cochlodesma leanum. (See explanation of chart 26.)

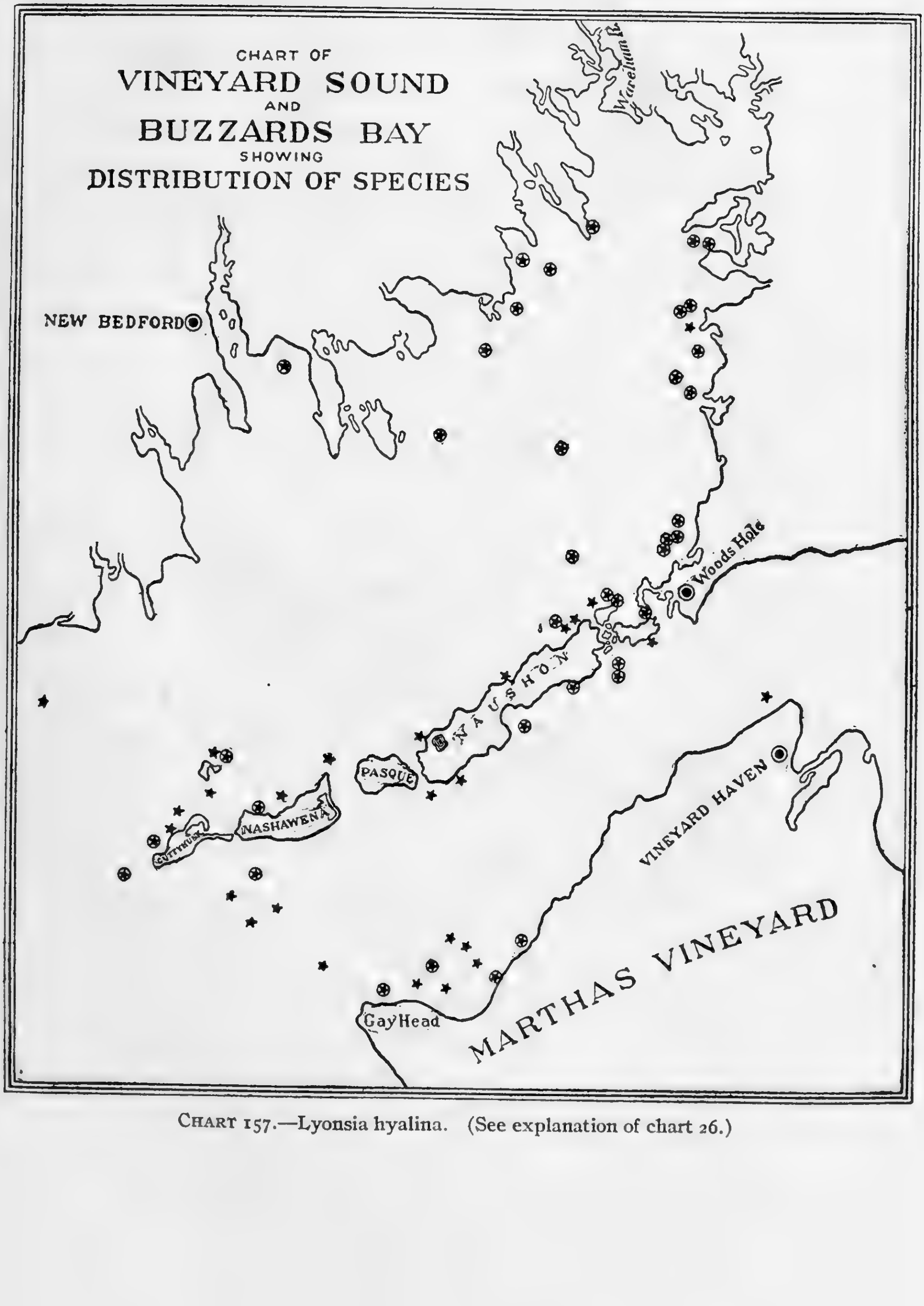


CHART 157.—Lyonsia hyalina. (See explanation of chart 26.)

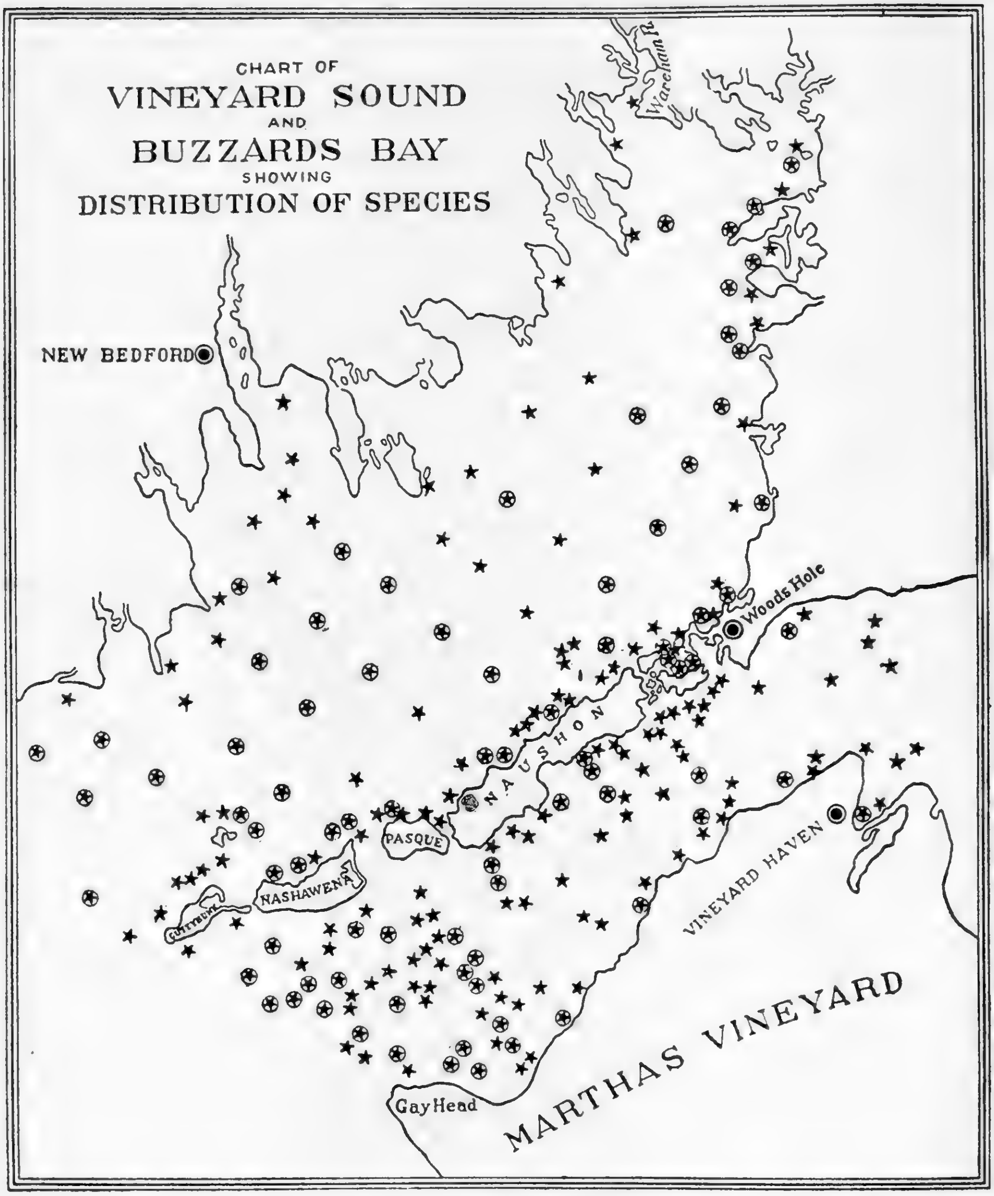


CHART 158.—Clidiophora gouldiana. (See explanation of chart 26.)

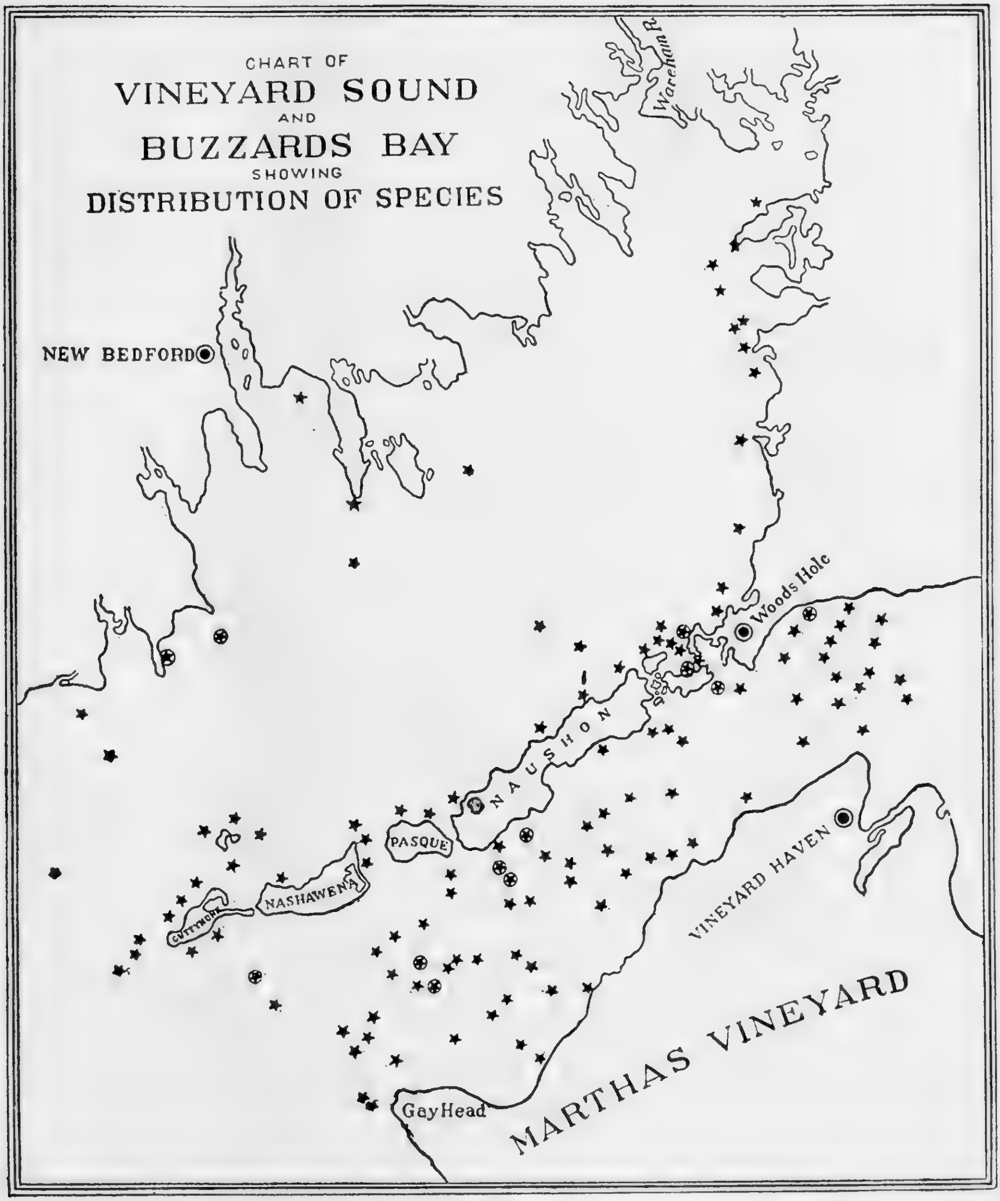


CHART 159.—Corbula contracta. (See explanation of chart 26.)

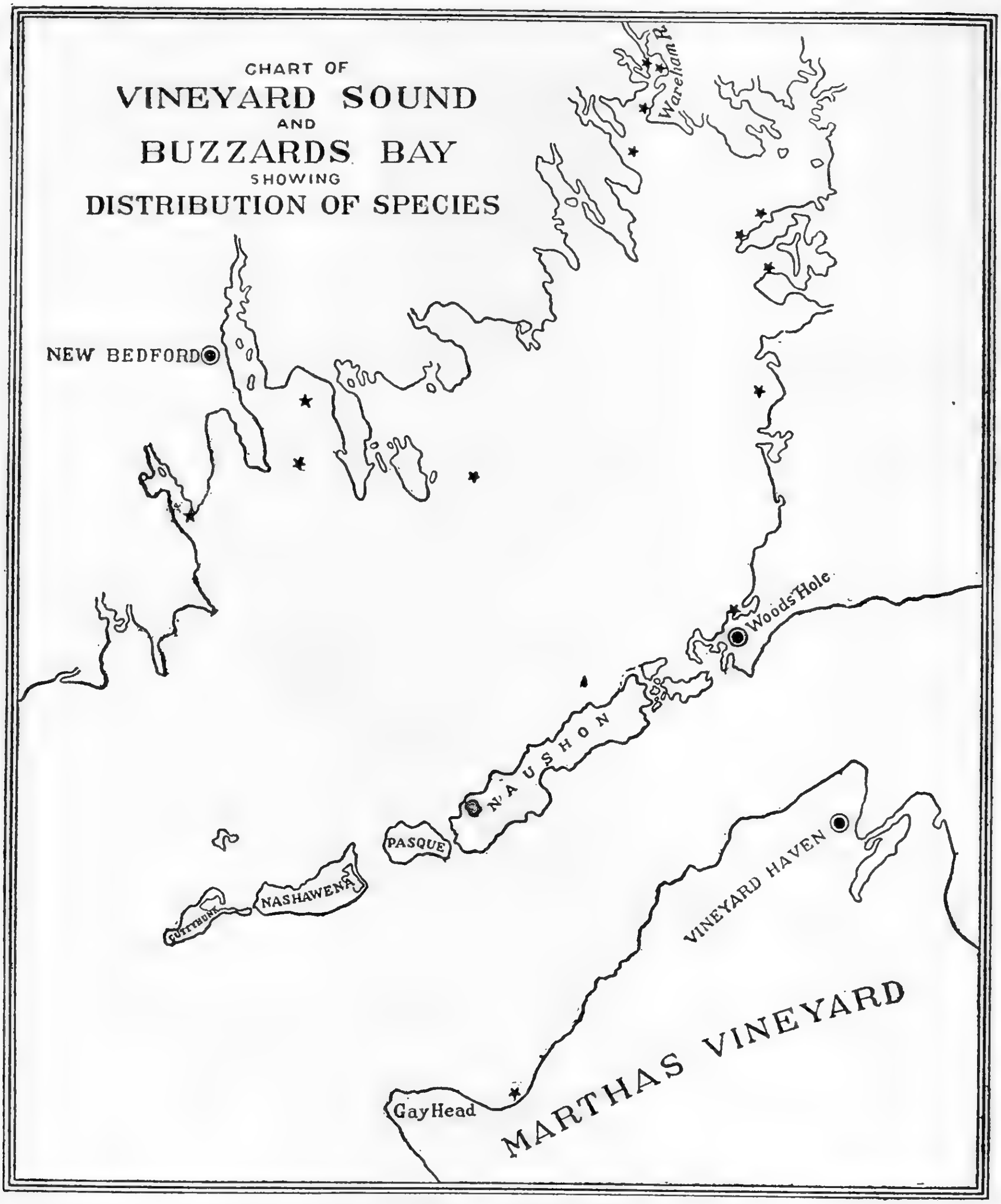


CHART 160.—Mya arenaria. (See explanation of chart 26.)

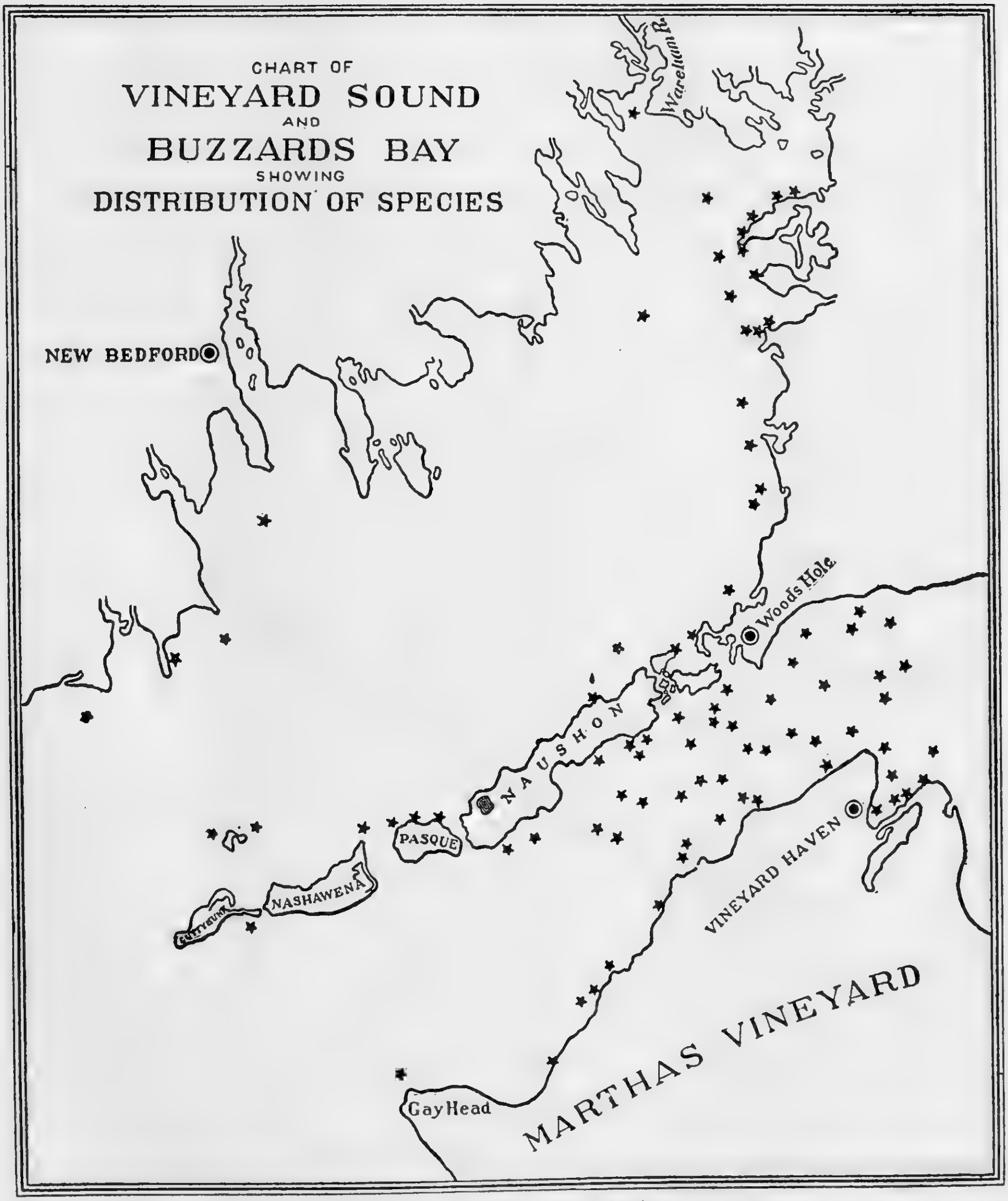


CHART 161.—Chætopleura apiculata.

Despite the omission of the circles from this chart, nearly all of our records are for living specimens.

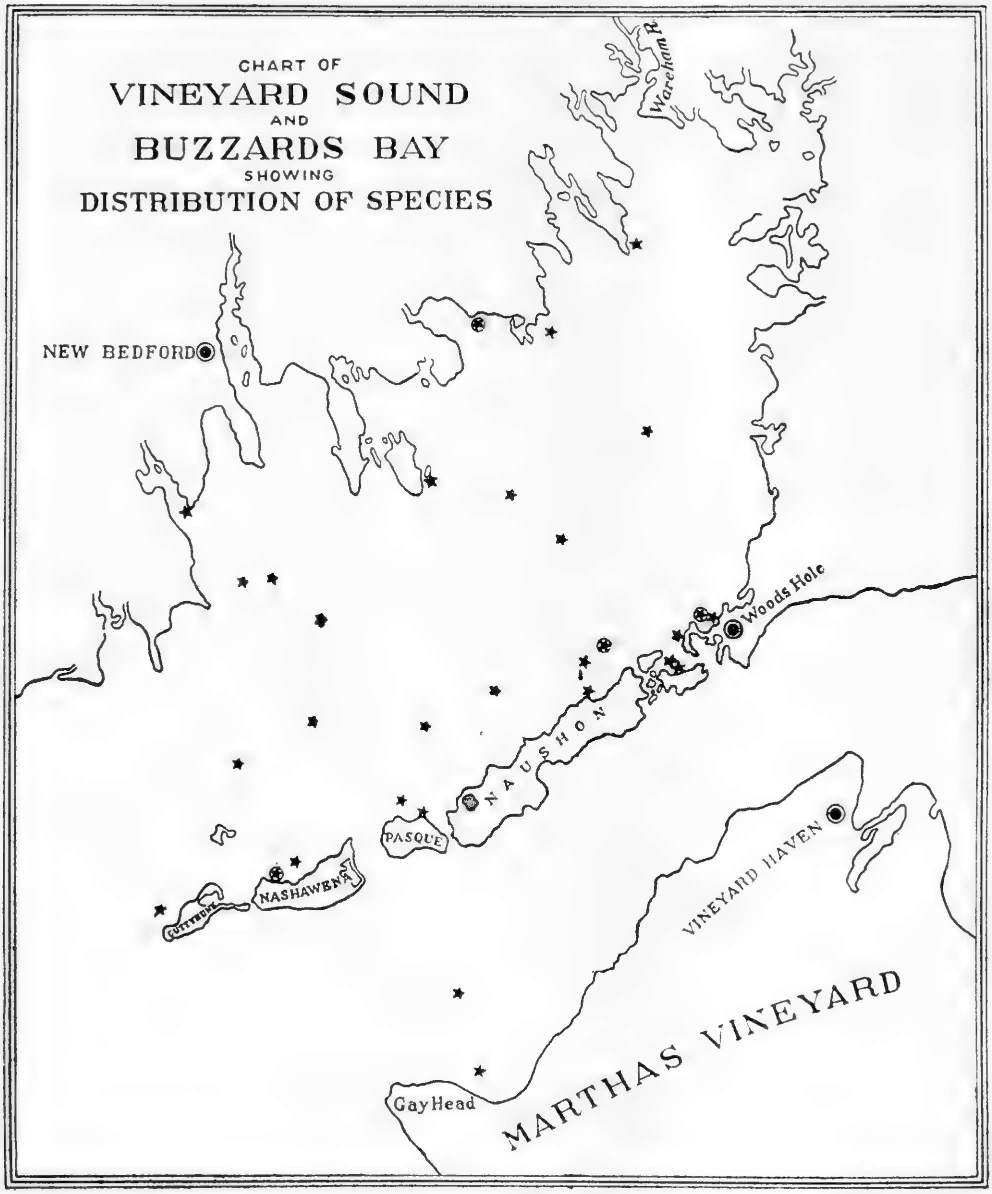


CHART 162.—Tornatina canaliculata. (See explanation of chart 26.)

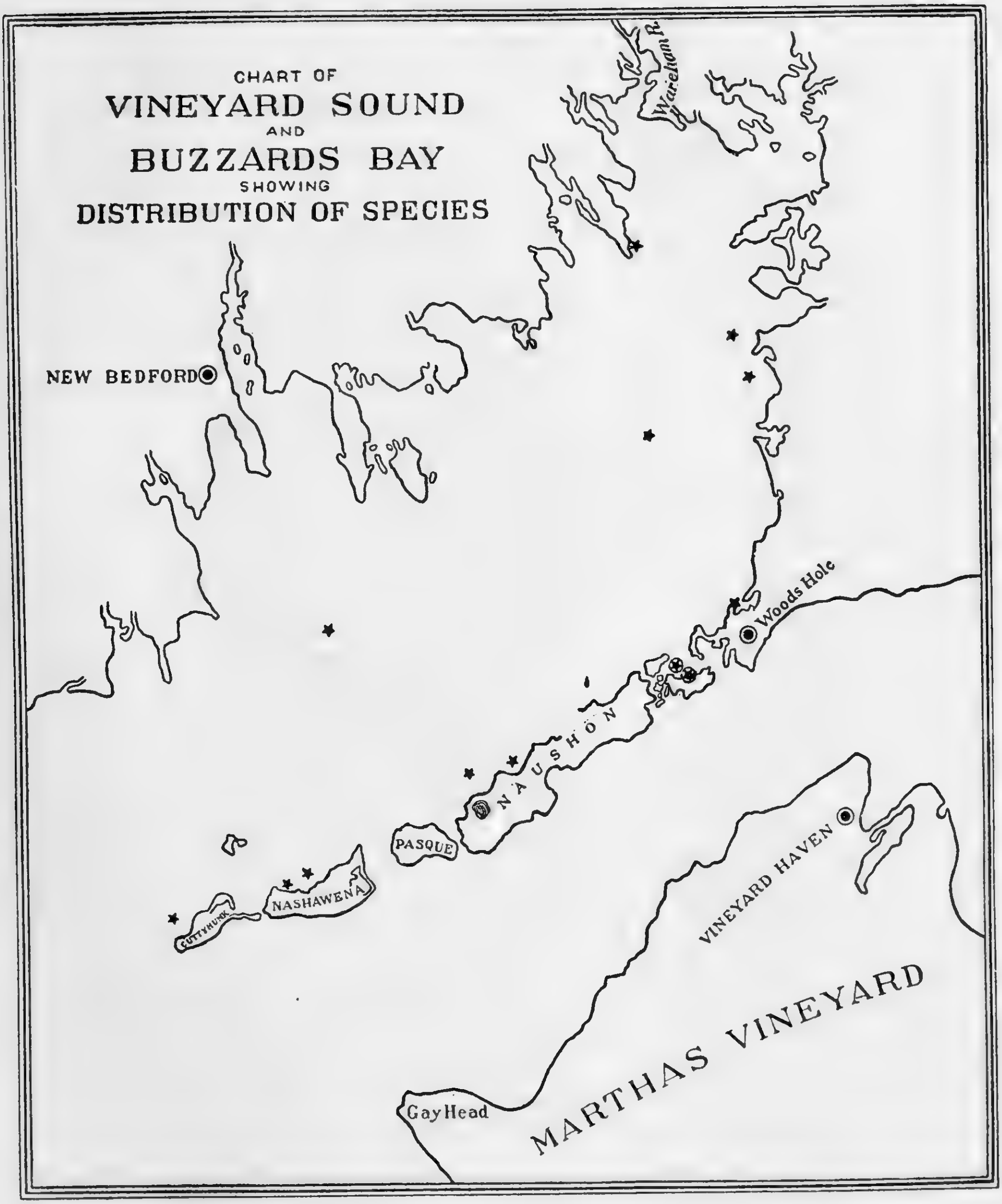


CHART 163.—Cylichnella oryza. (See explanation of chart 26.)

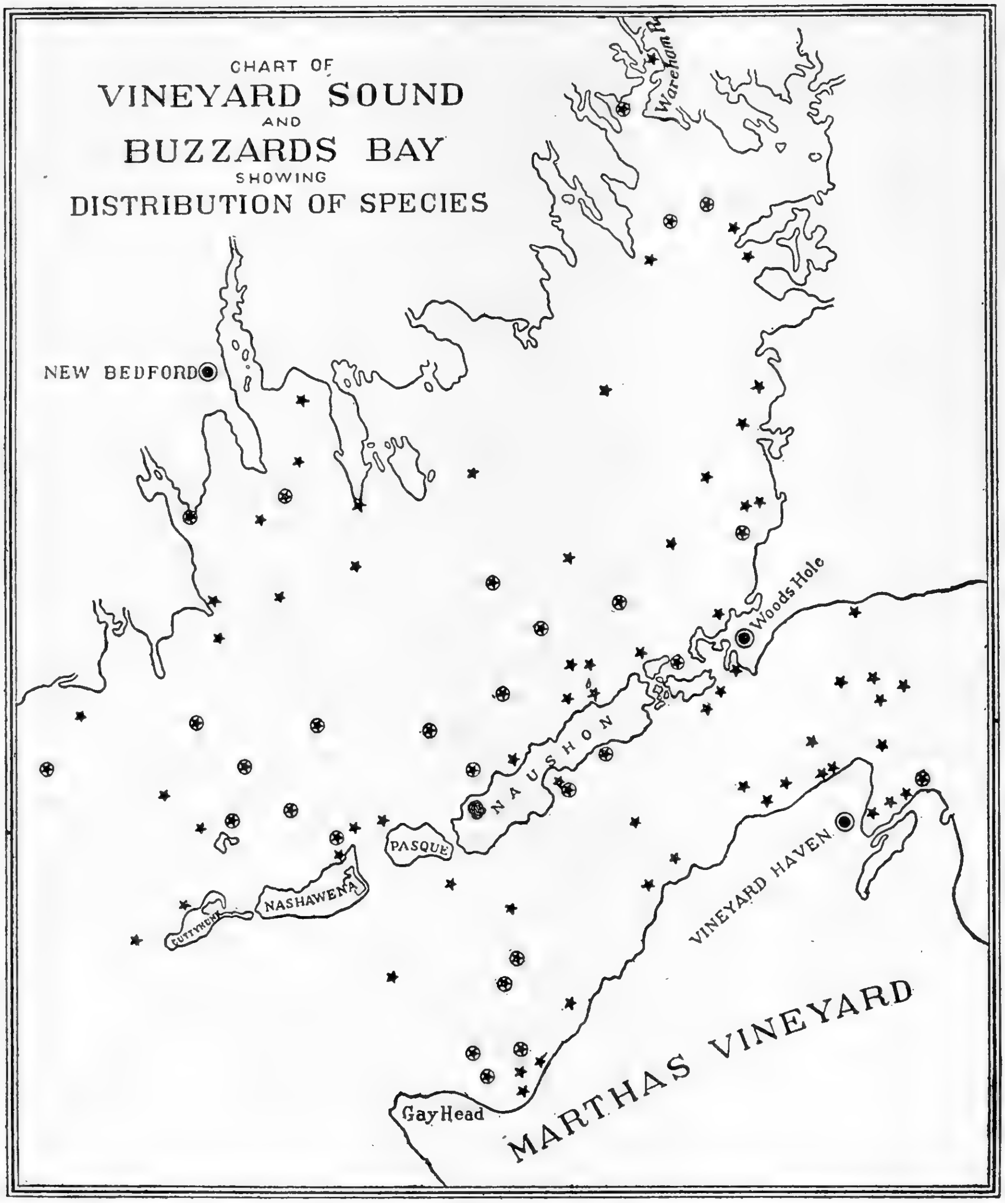


CHART 164.—Busycon canaliculatum. (See explanation of chart 26.)

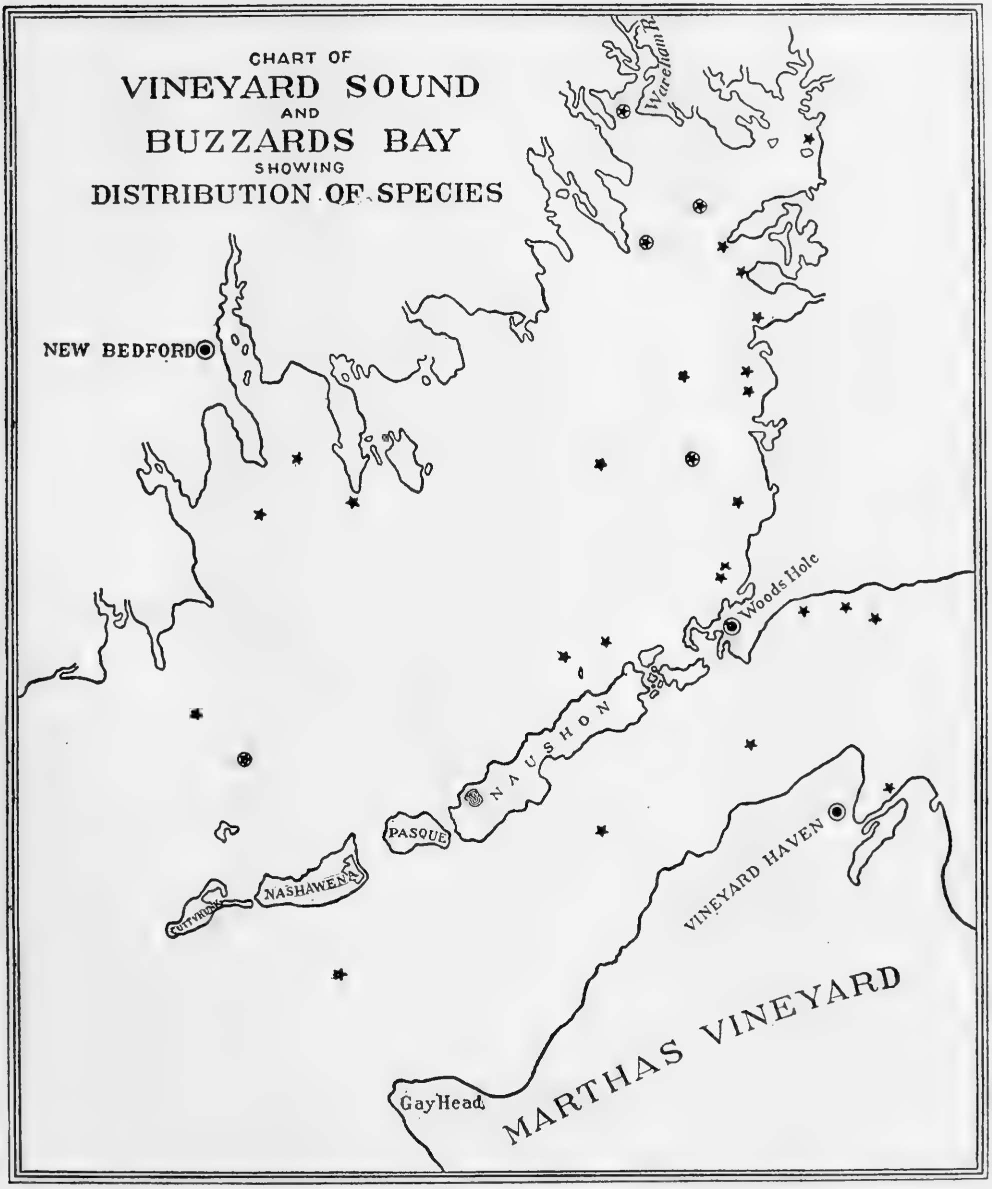


CHART 165.—Busycon carica. (See explanation of chart 26.)

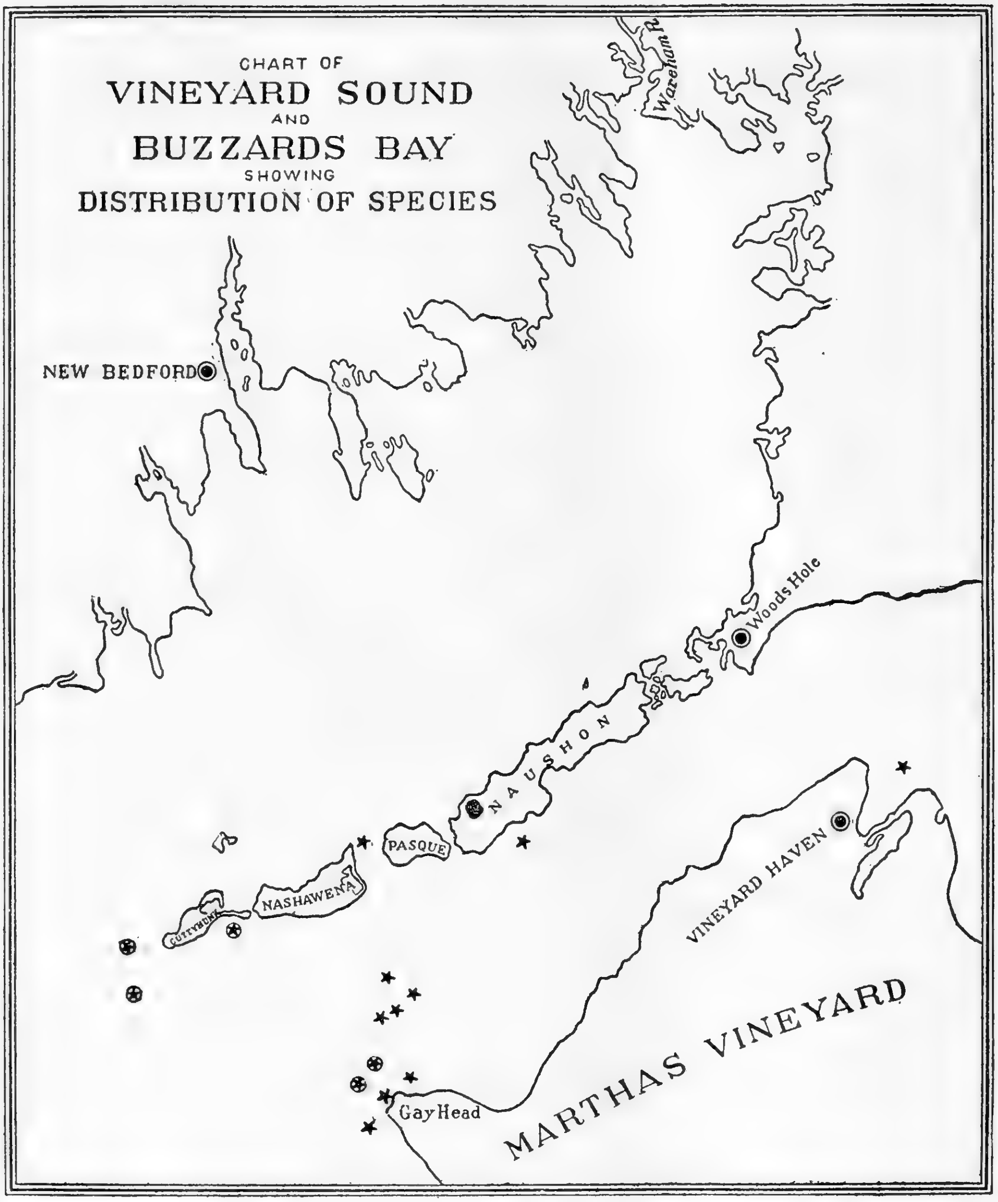


CHART 166.—Buccinum undatum. (See explanation of chart 26.)

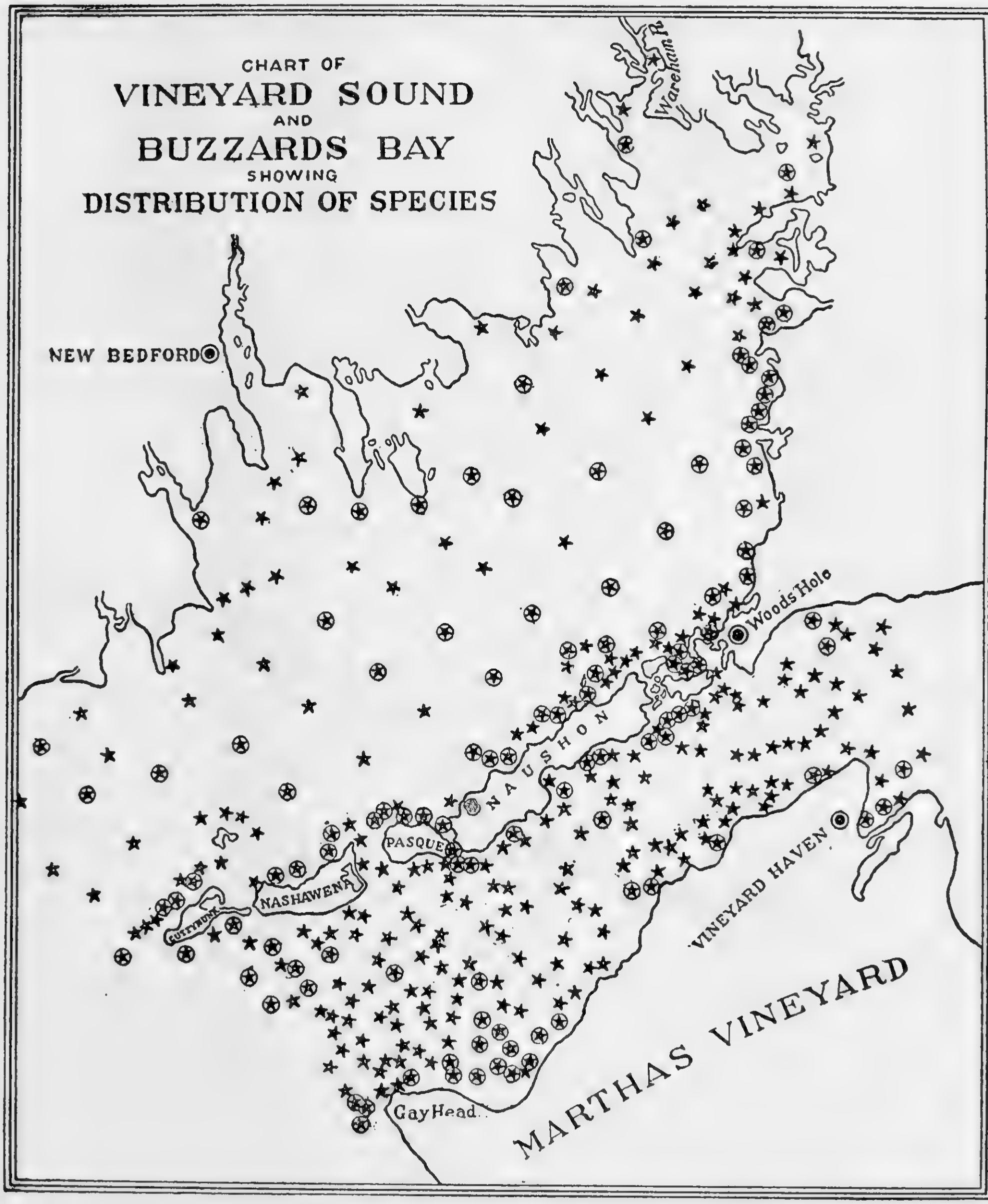


CHART 167.—Tritia trivittata. (See explanation of chart 26.)

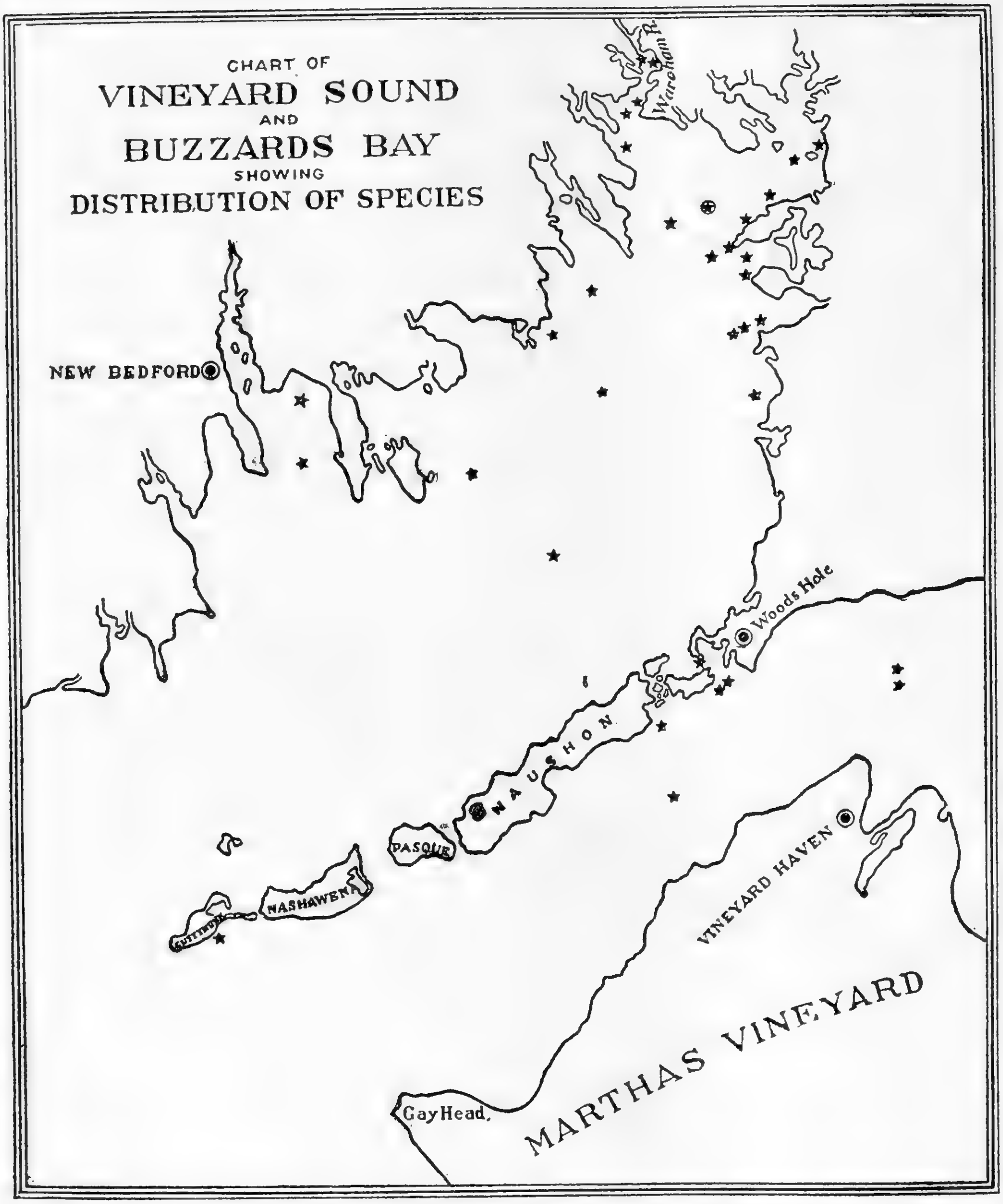


CHART 168.—Ilyanassa obsoleta. (See explanation of chart 26.)

For the most part shells which had been transported by hermit crabs.

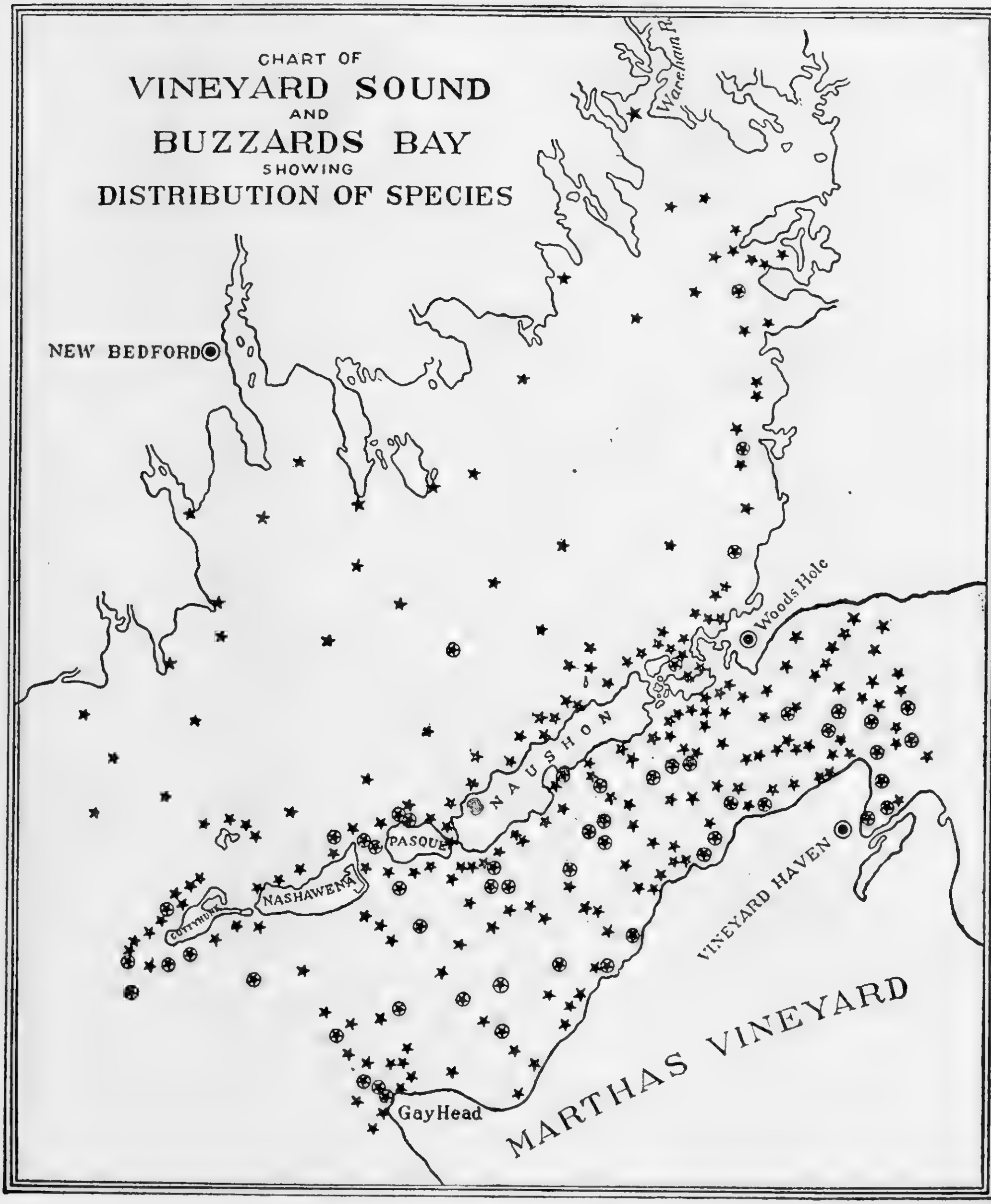


CHART 169.—Anachis avara. (See explanation of chart 26.)

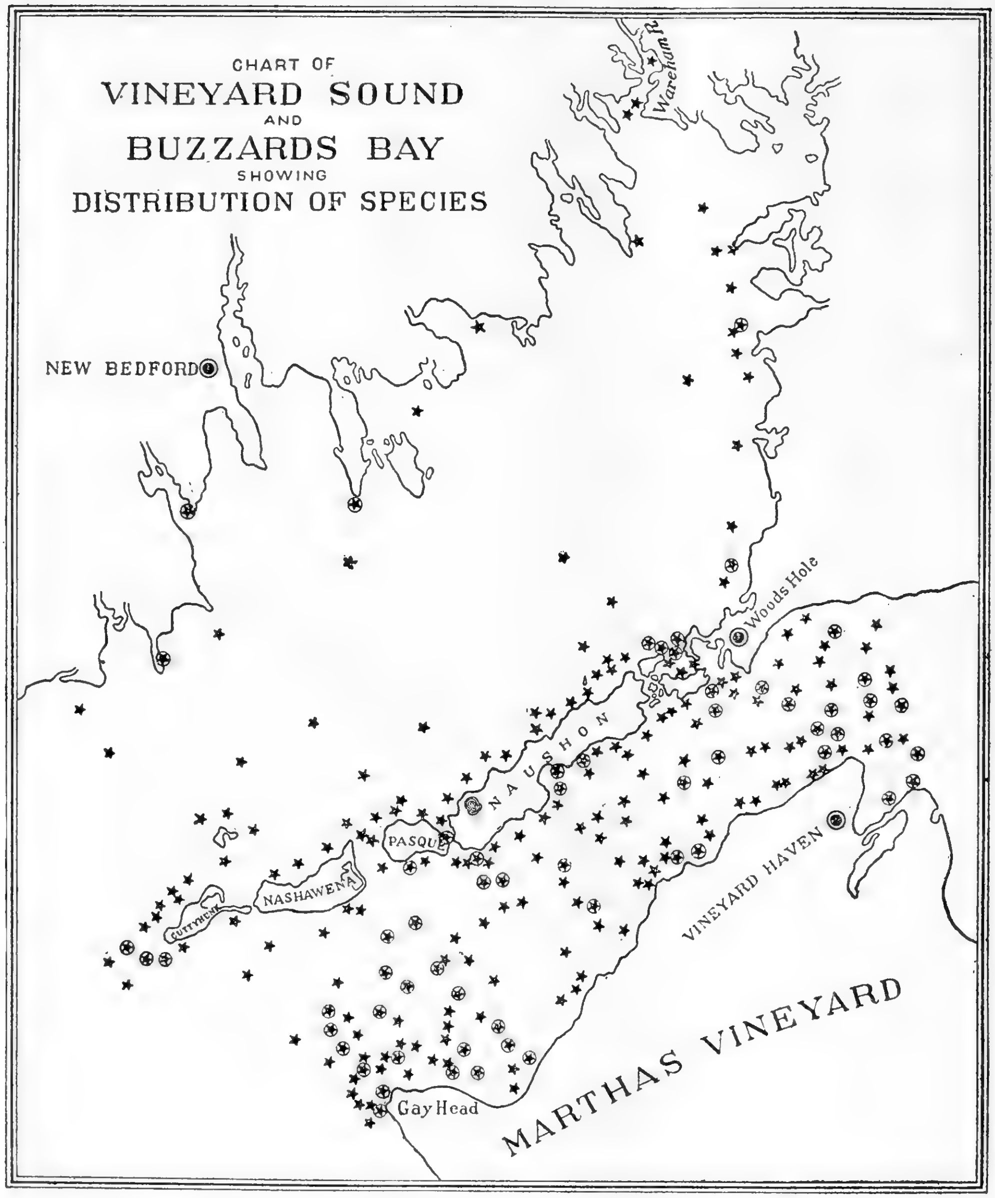


CHART 170.—Astyris lunata. (See explanation of chart 26.)

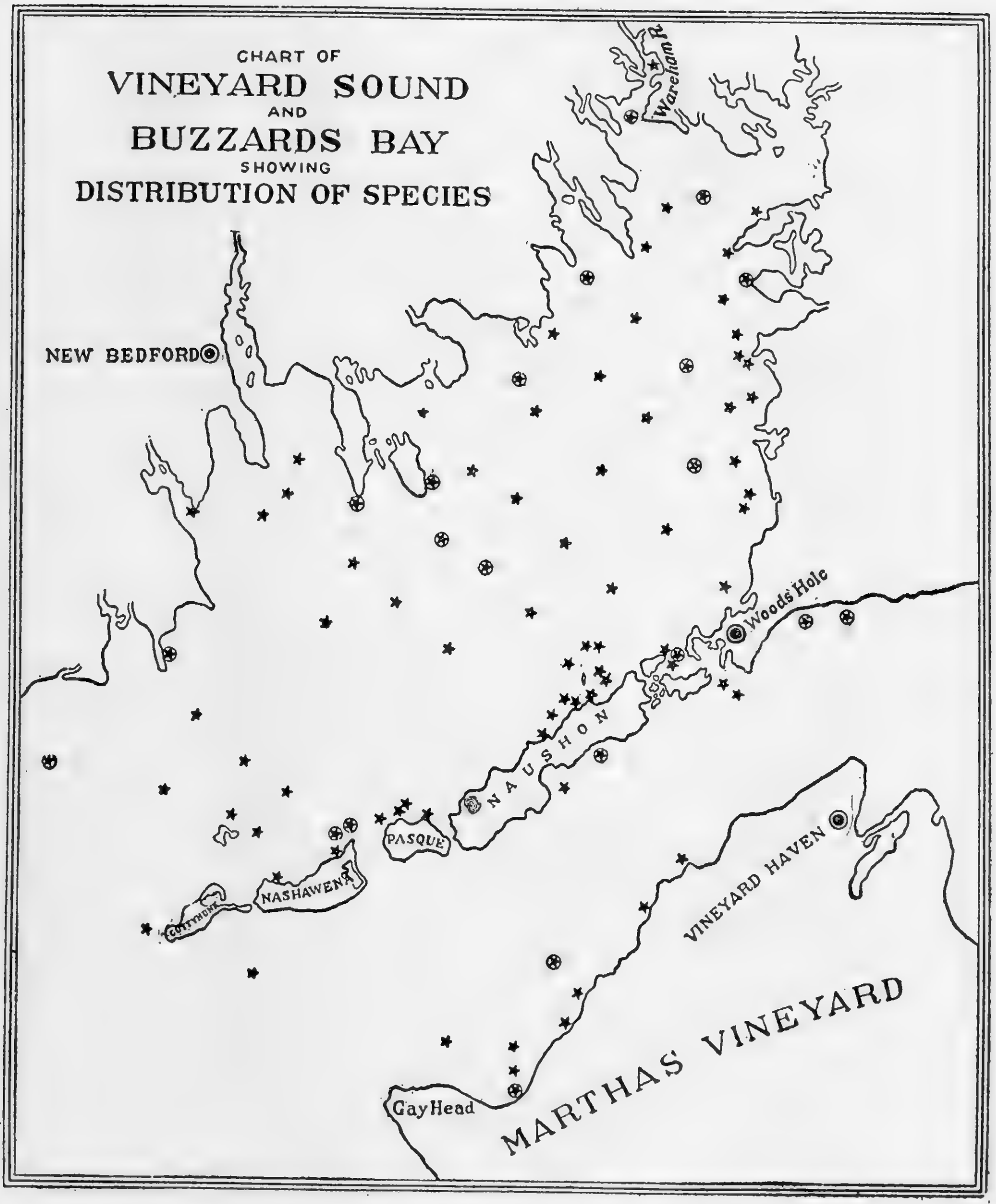


CHART 171.—Eupleura caudata. (See explanation of chart 26.)

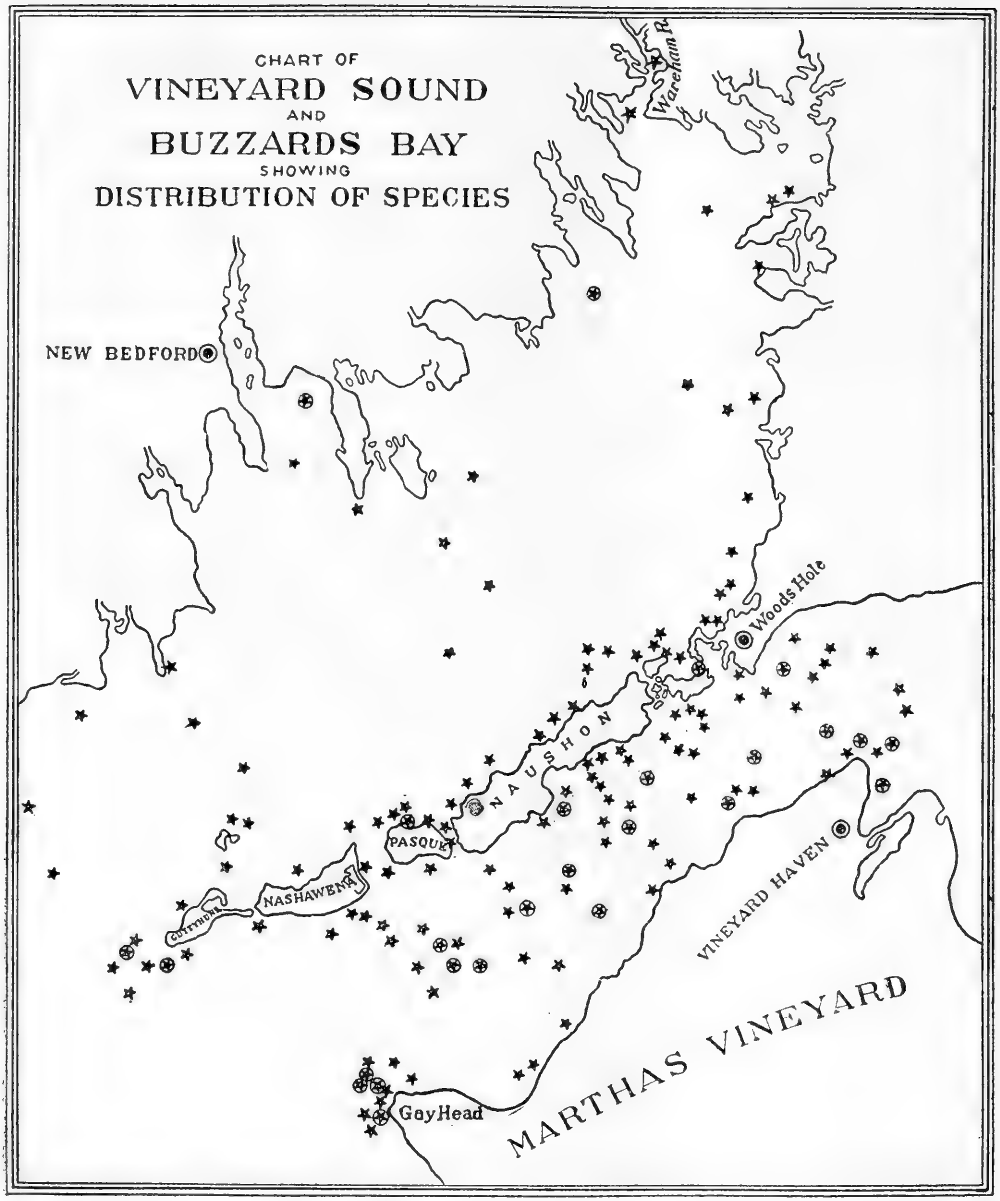


CHART 172.—Urosalpinx cinereus. (See explanation of chart 26.)

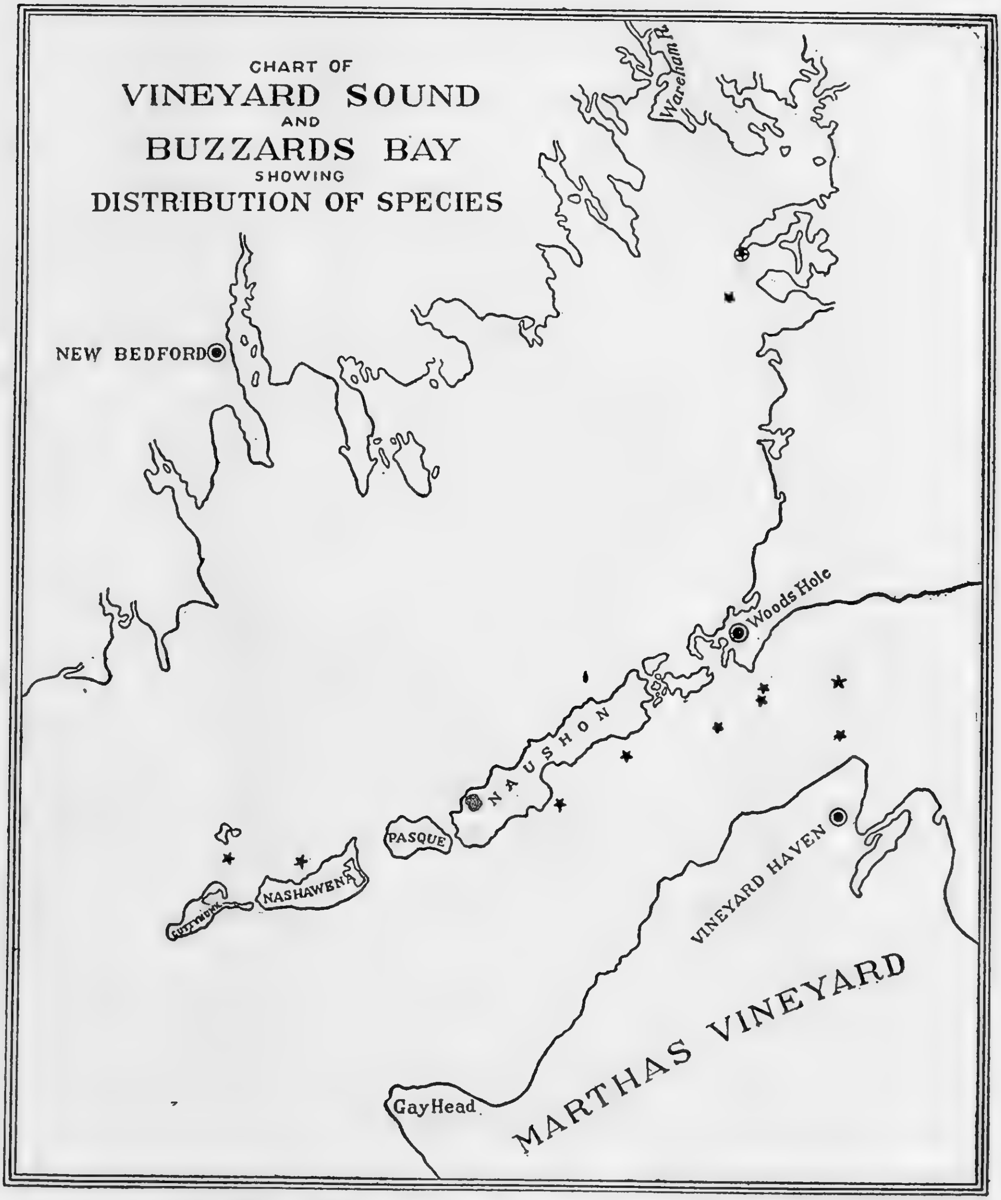


CHART 173.—Eulima conoidea. (See explanation of chart 26.)

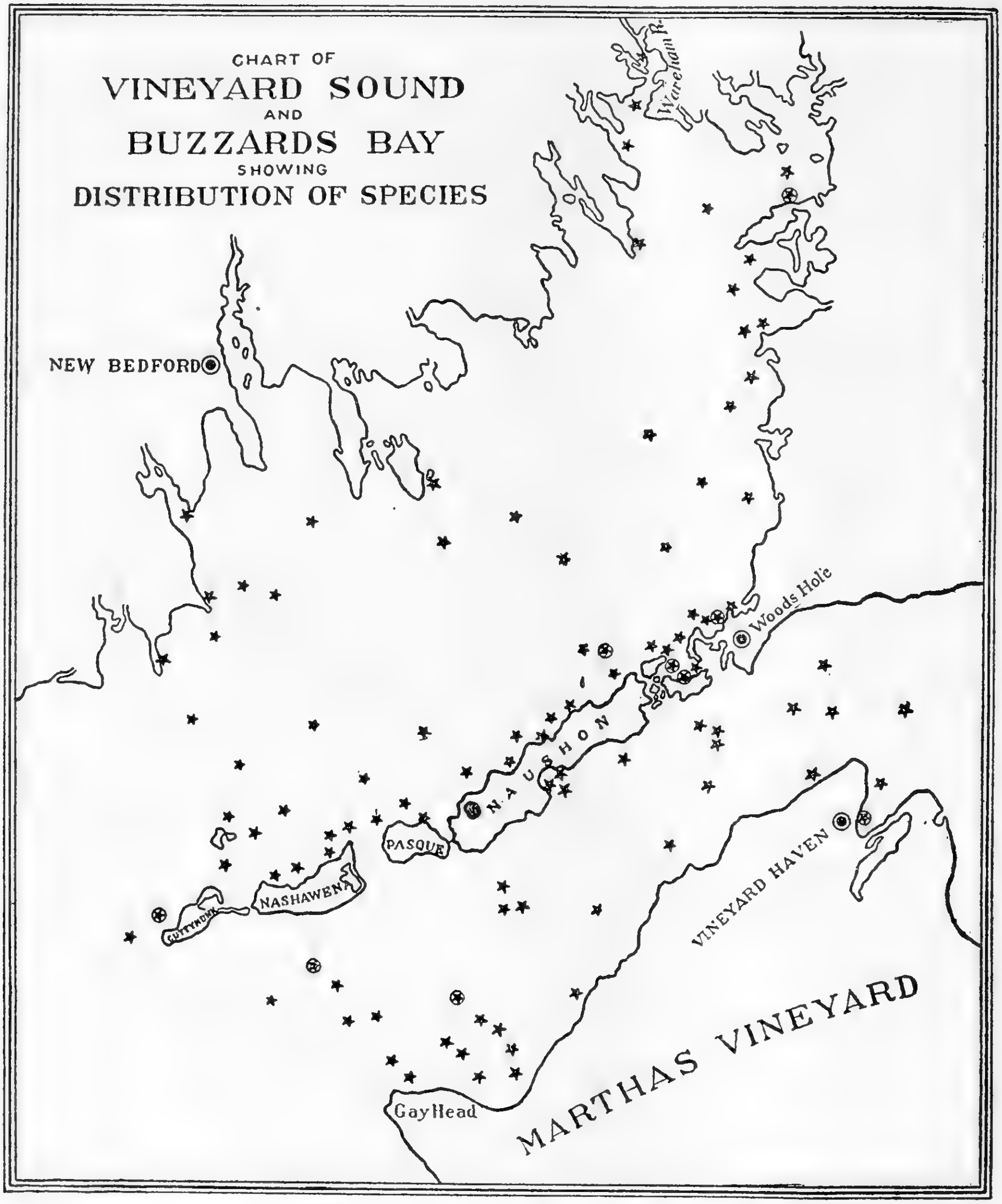


CHART 174.—Turbonilla sp. (See explanation of chart 26.)

Owing to a confusion in the earlier records, the distribution of all members of this genus has been plotted upon a single chart.

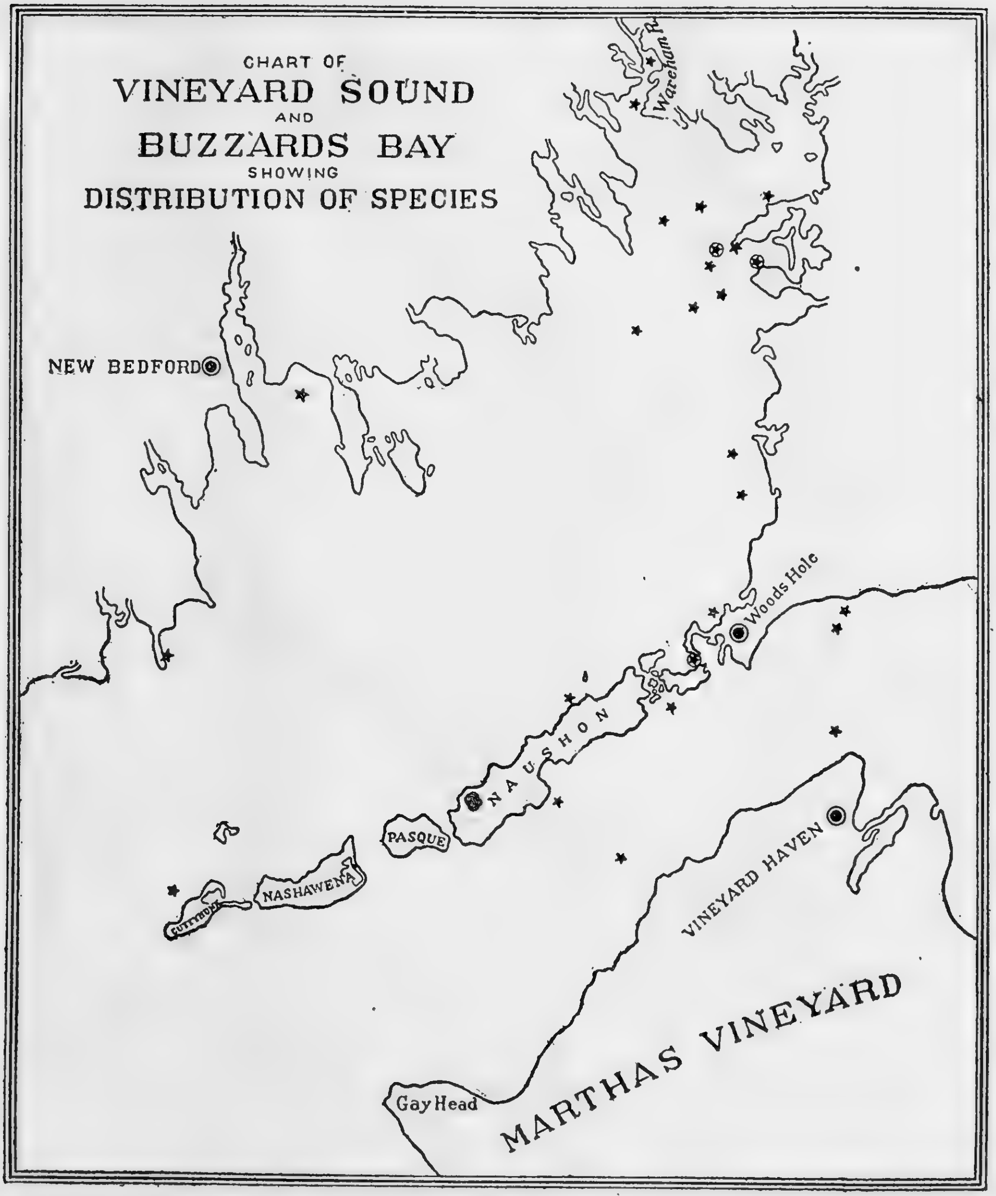


CHART 175.—Seila terebralis. (See explanation of chart 26.)

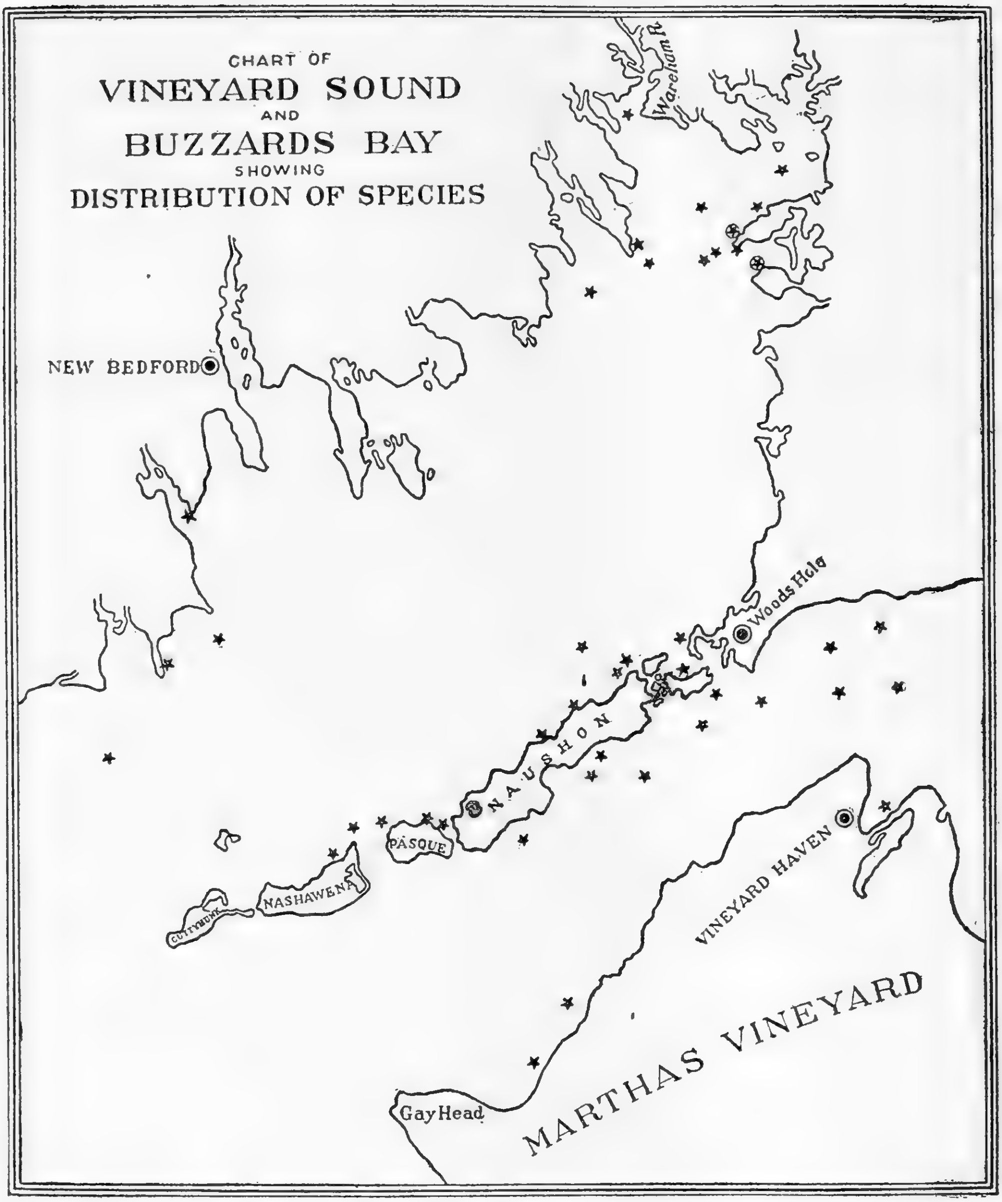


CHART 176.—Cerithiopsis emersonii. (See explanation of chart 26.)

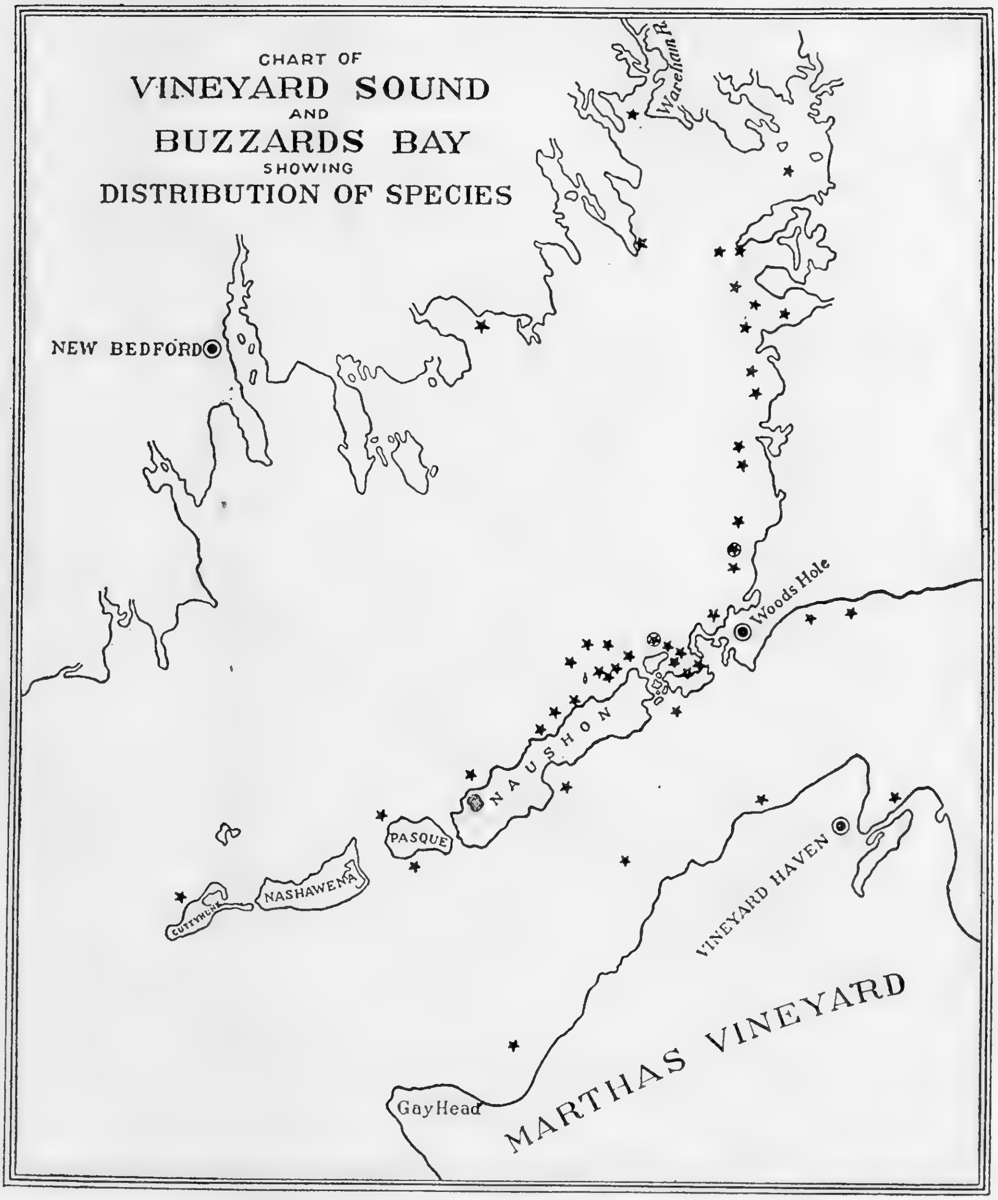


CHART 177.—Bittium alternatum. (See explanation of chart 26.)

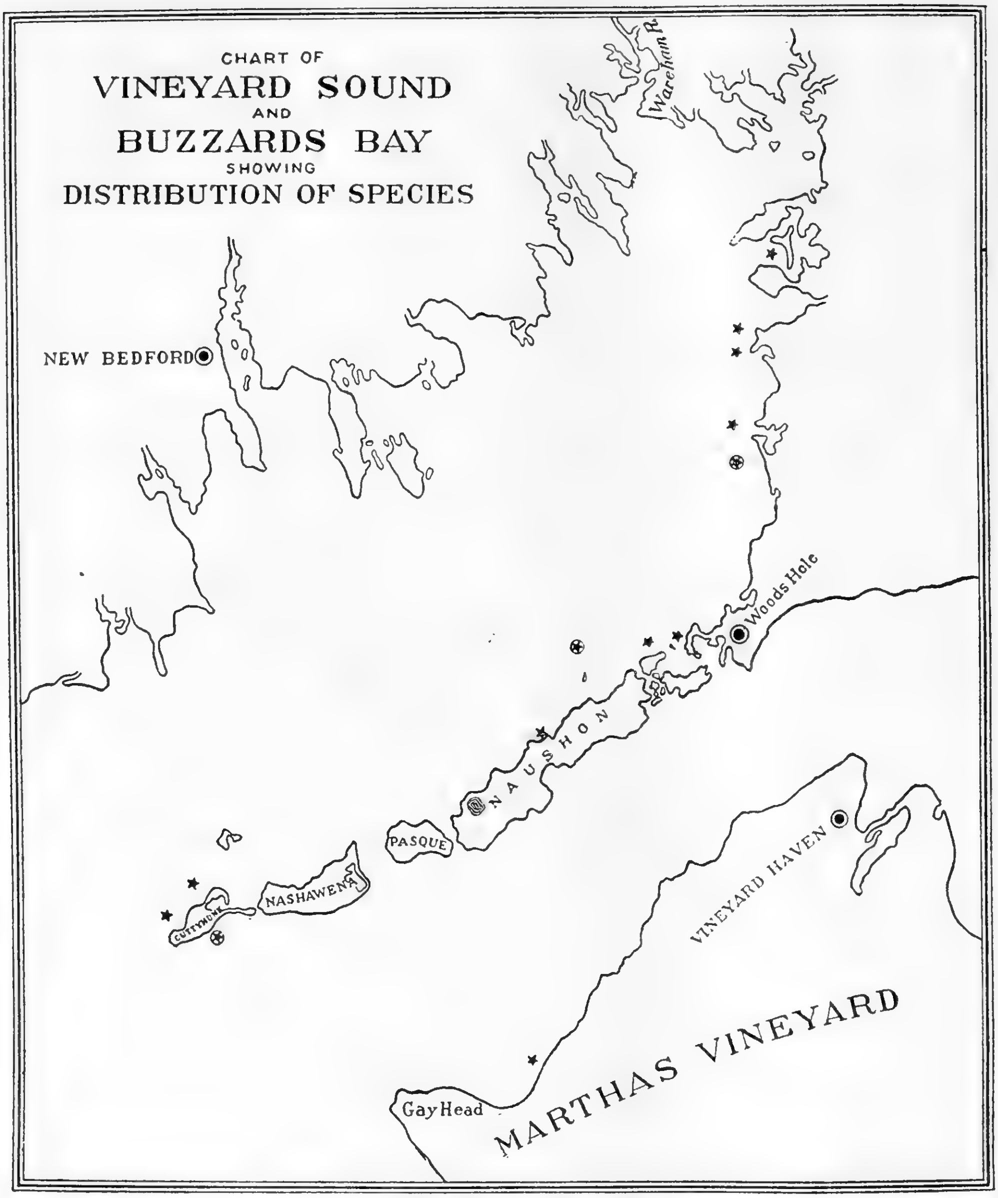


CHART 178.—Cæcum cooperi. (See explanation of chart 26.)

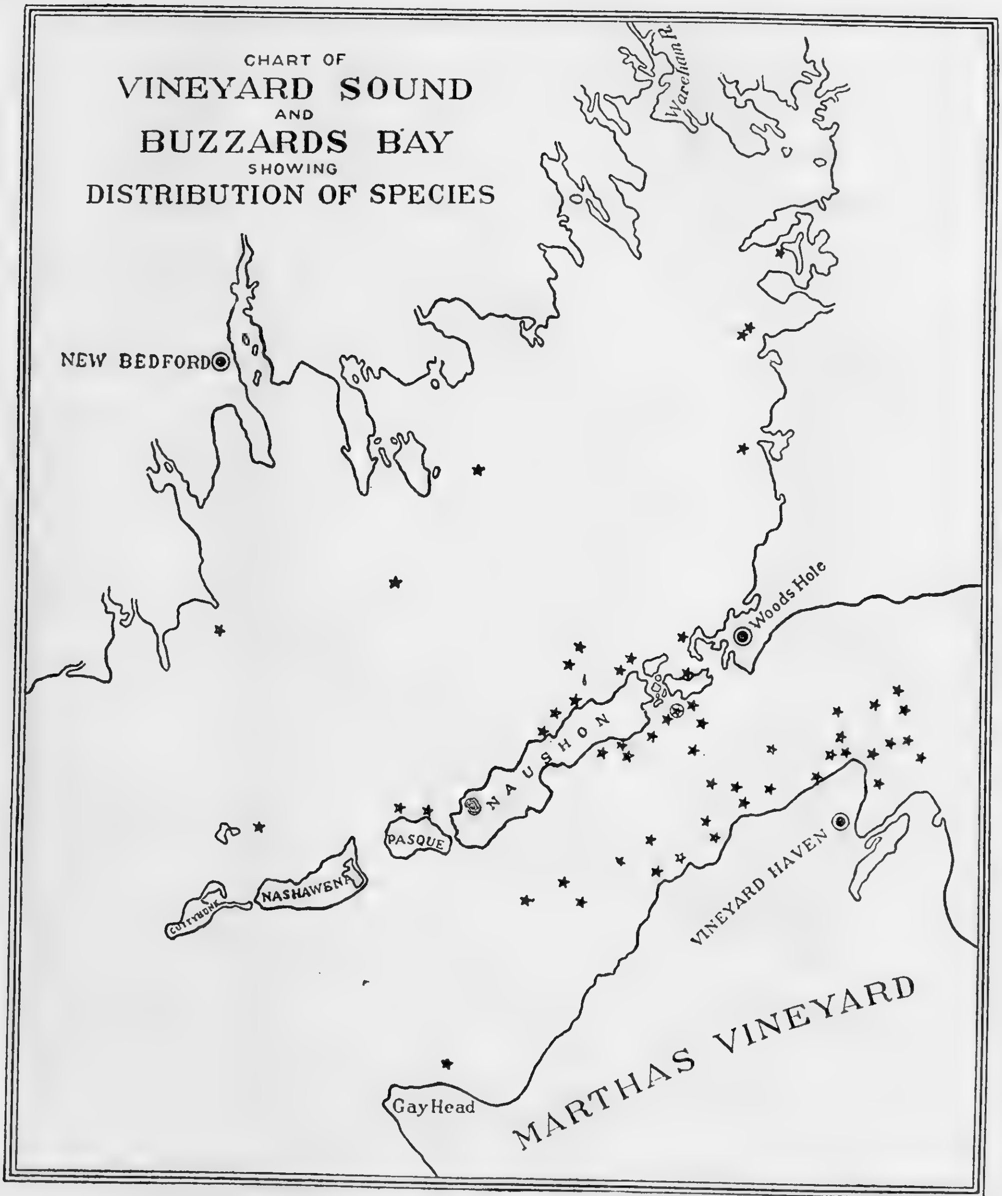


CHART 179.—Vermicularia spirata. (See explanation of chart 26.)

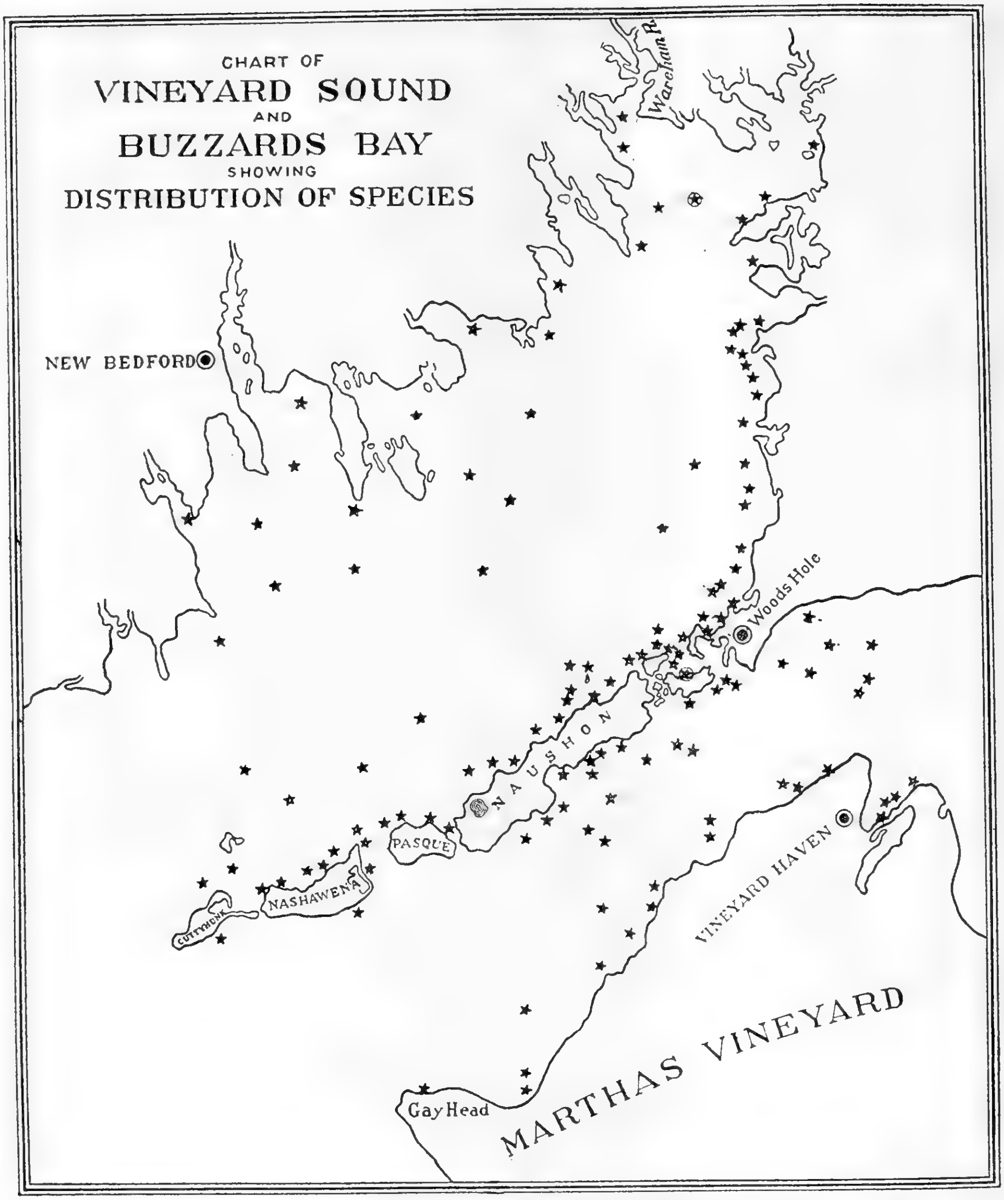


CHART 180.—Littorina litorea. (See explanation of chart 26.)

In nearly every case these records are for shells which had been transported by hermit crabs.

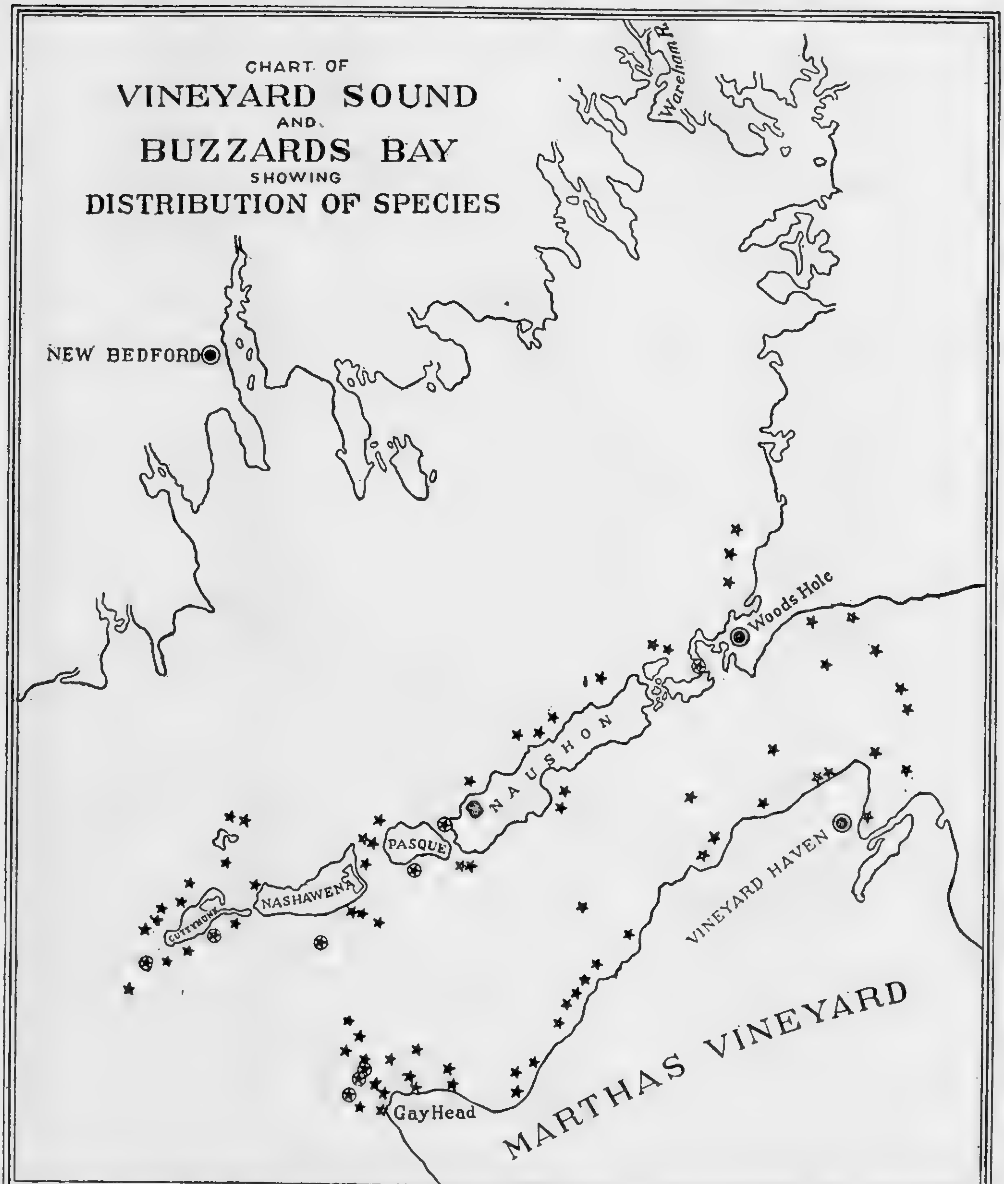


CHART 181.—Lacuna puteola. (See explanation of chart 26.)

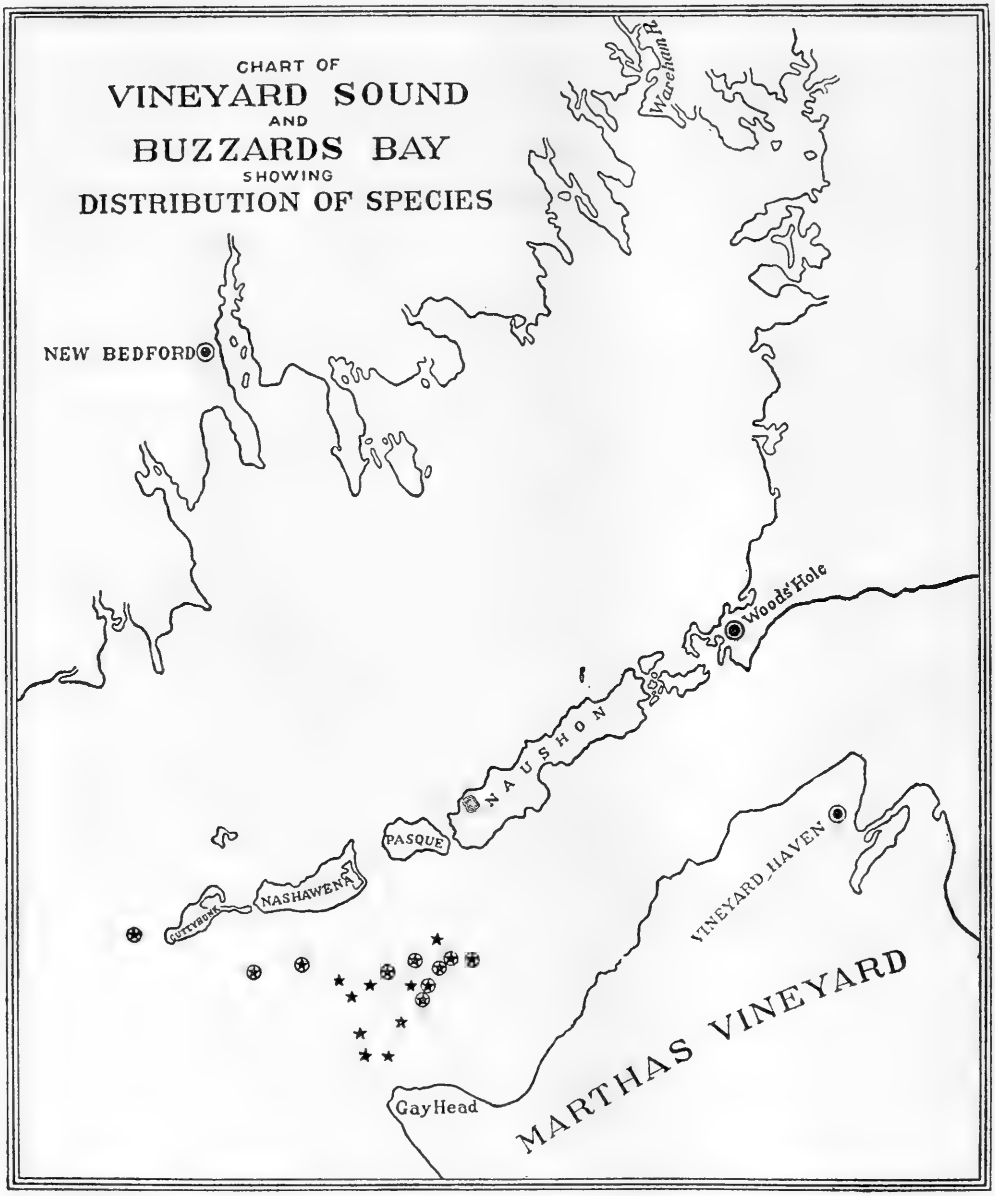


CHART 182.—Crucibulum striatum. (See explanation of chart 26.)

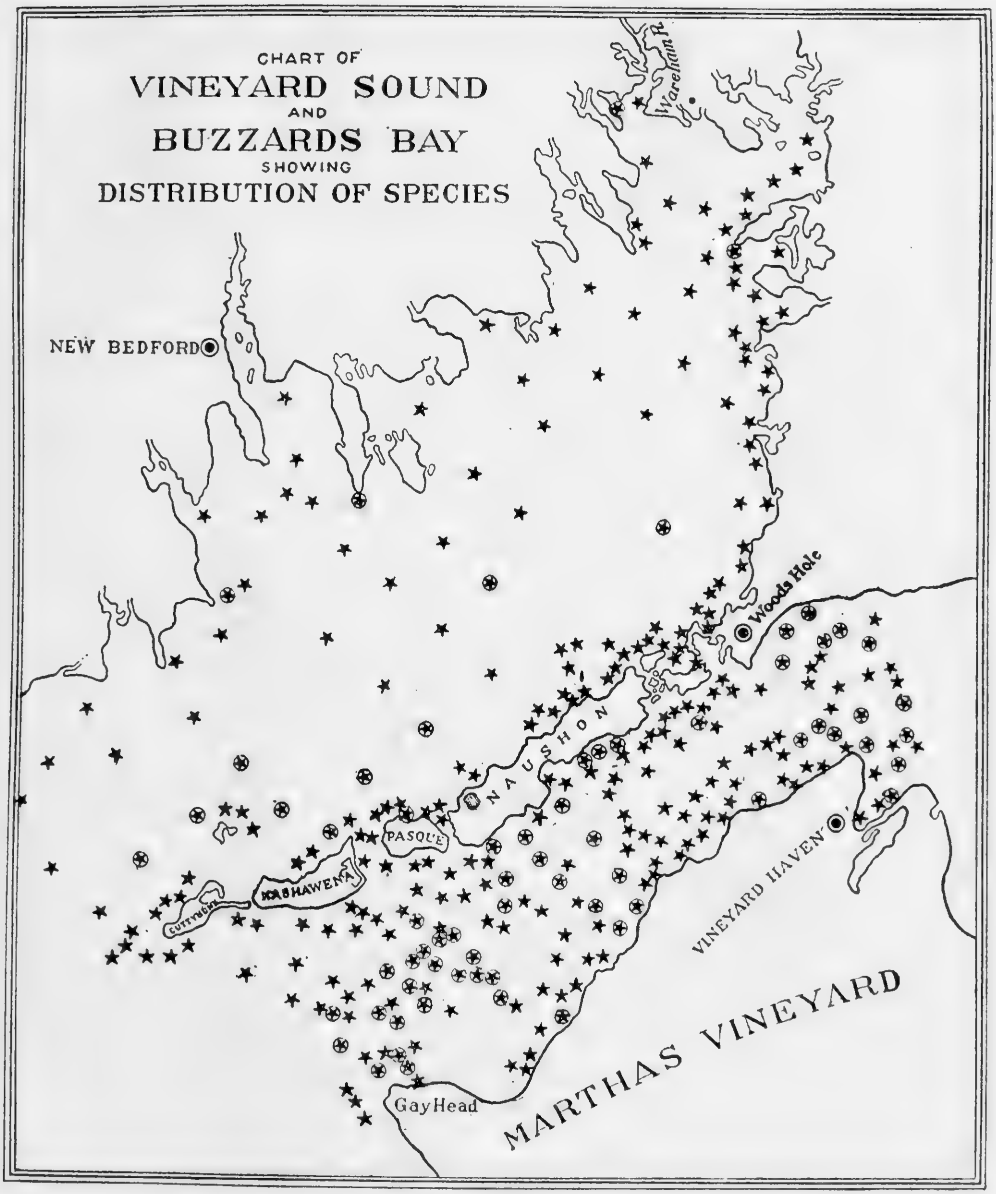


CHART 183.—Crepidula fornicata. (See explanation of chart 26.)

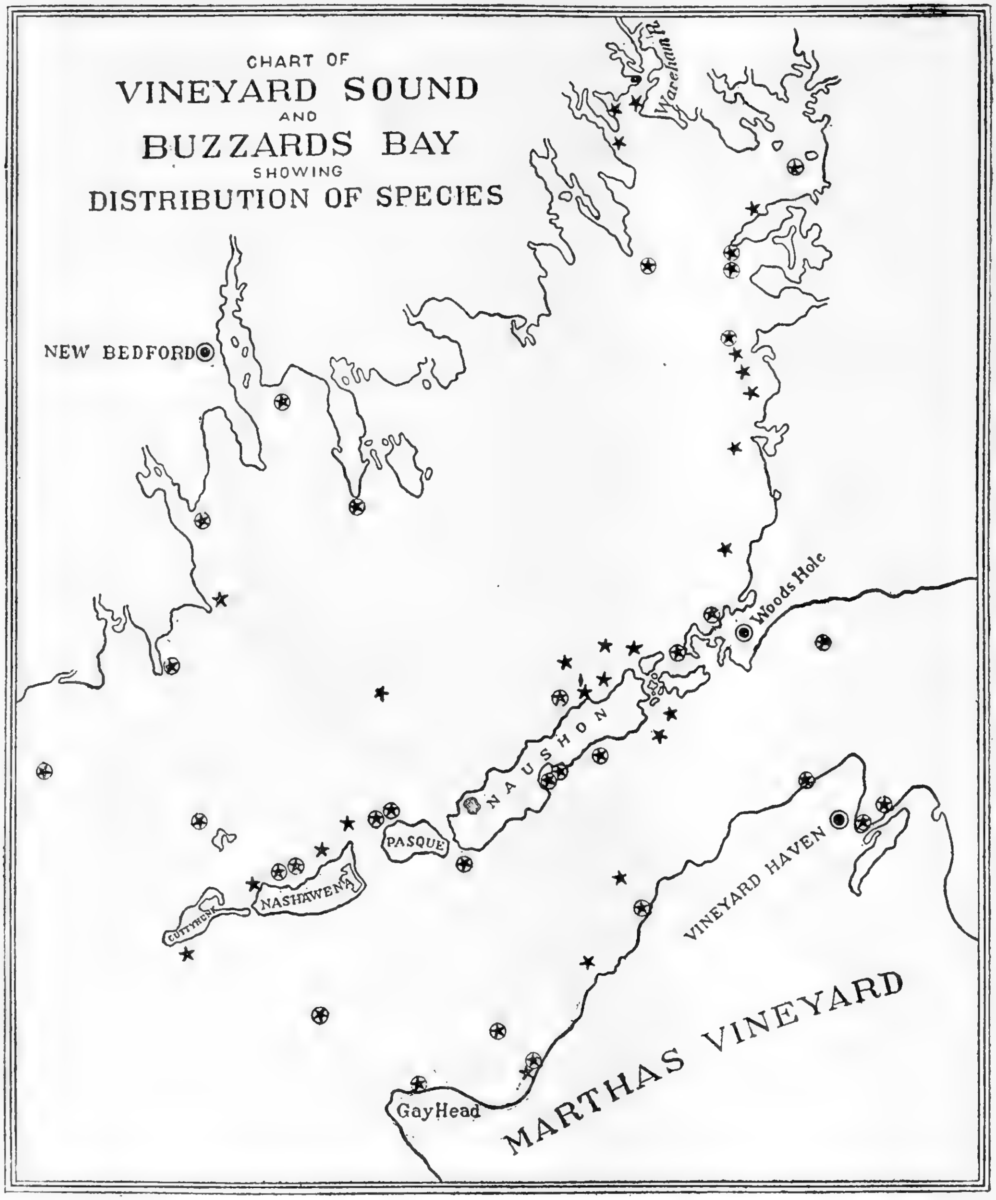


CHART 184.—Crepidula convexa. (See explanation of chart 26.)

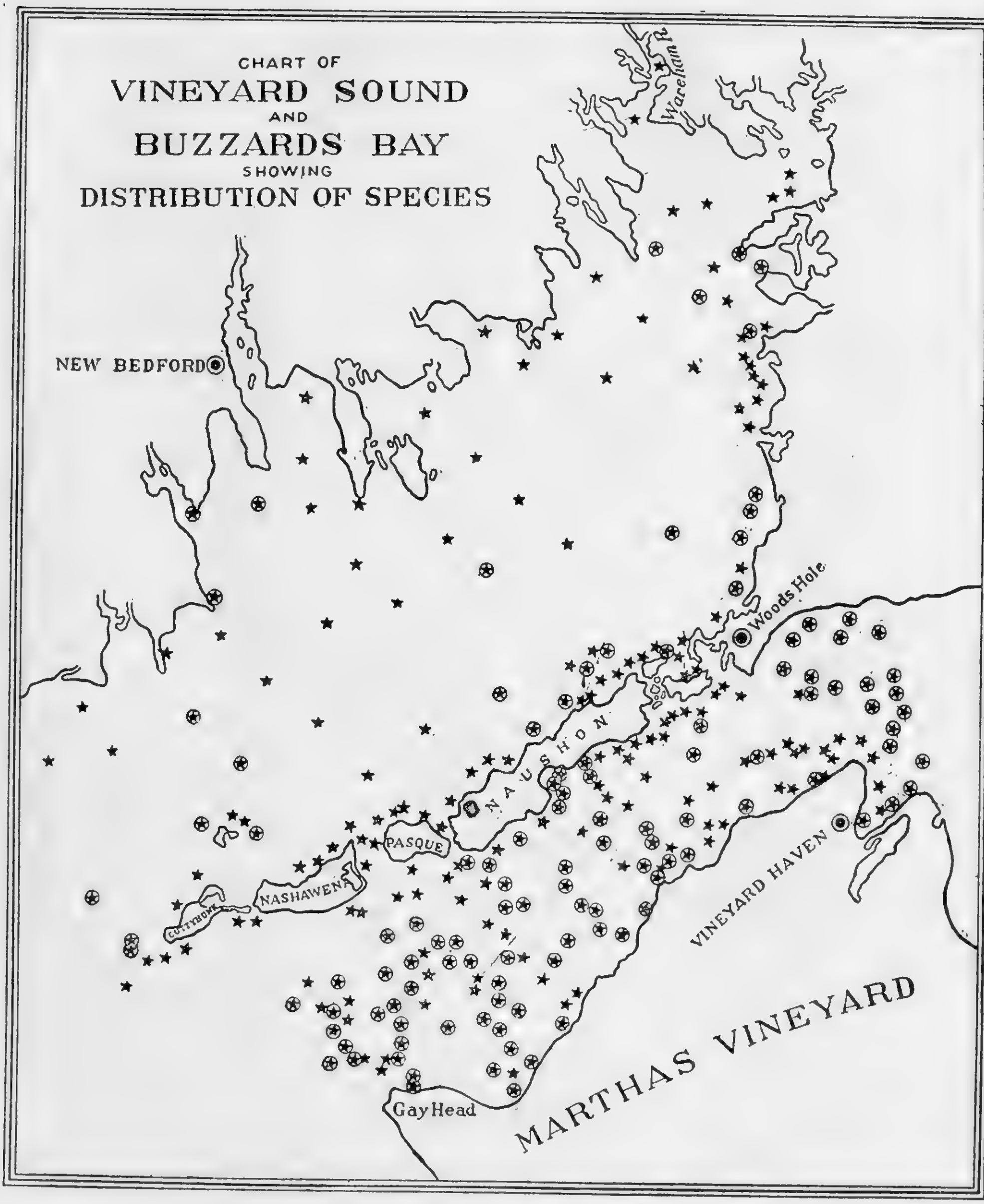


CHART 185.—Crepidula plana. (See explanation of chart 26.)

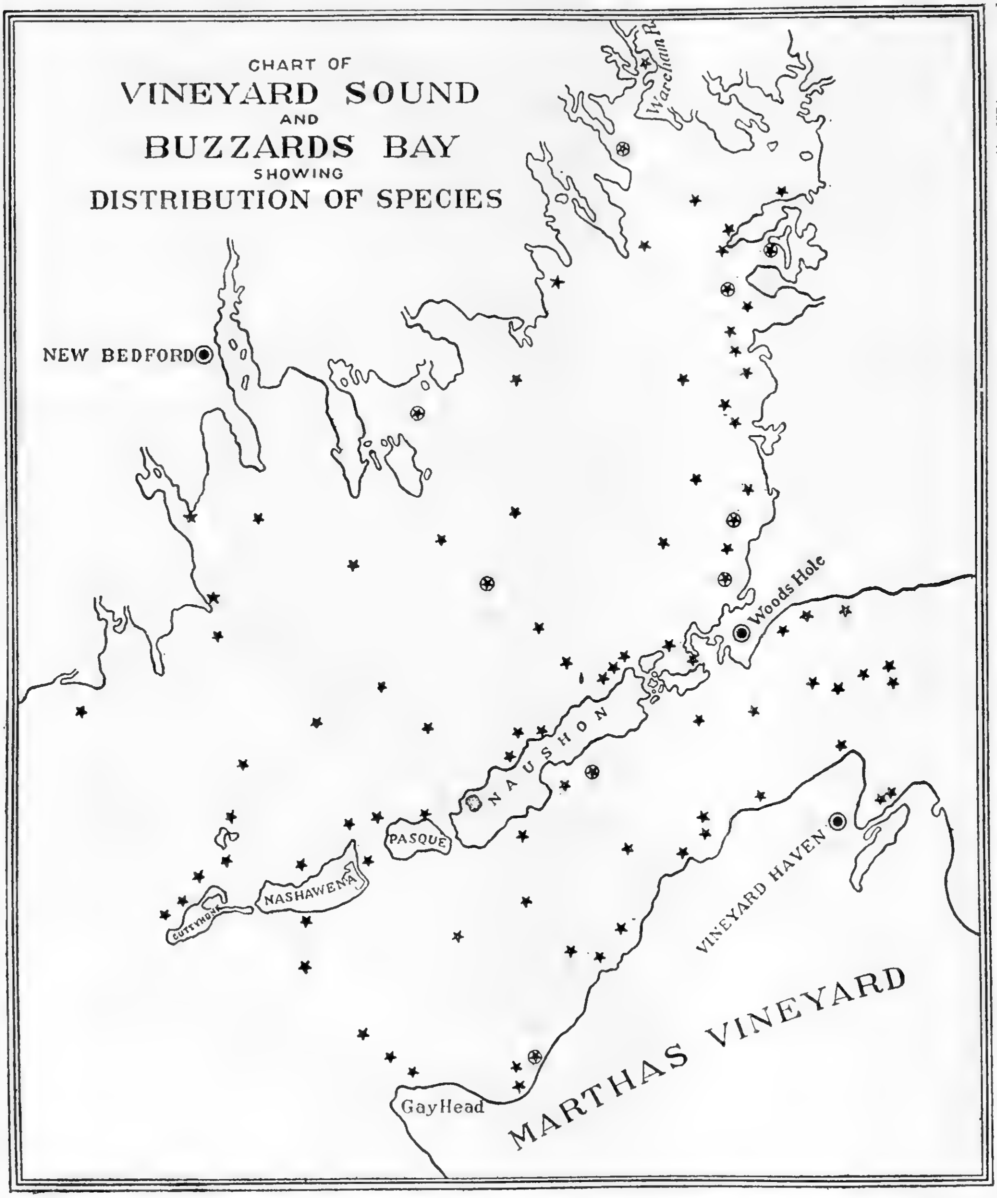


Chart 186.—Polynices duplicata. (See explanation of chart 26.)

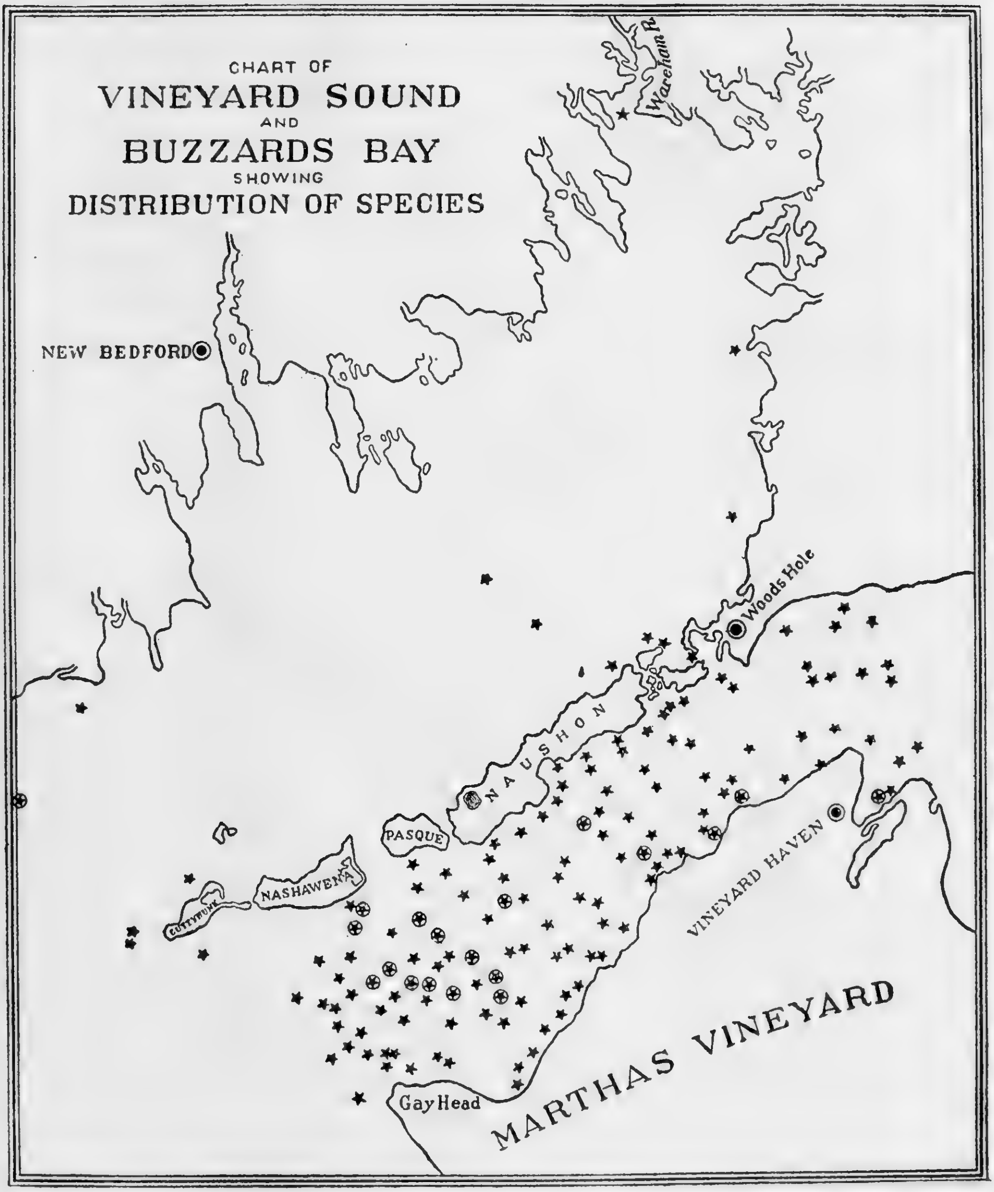


CHART 187.—Polynices heros. (See explanation of chart 26.)

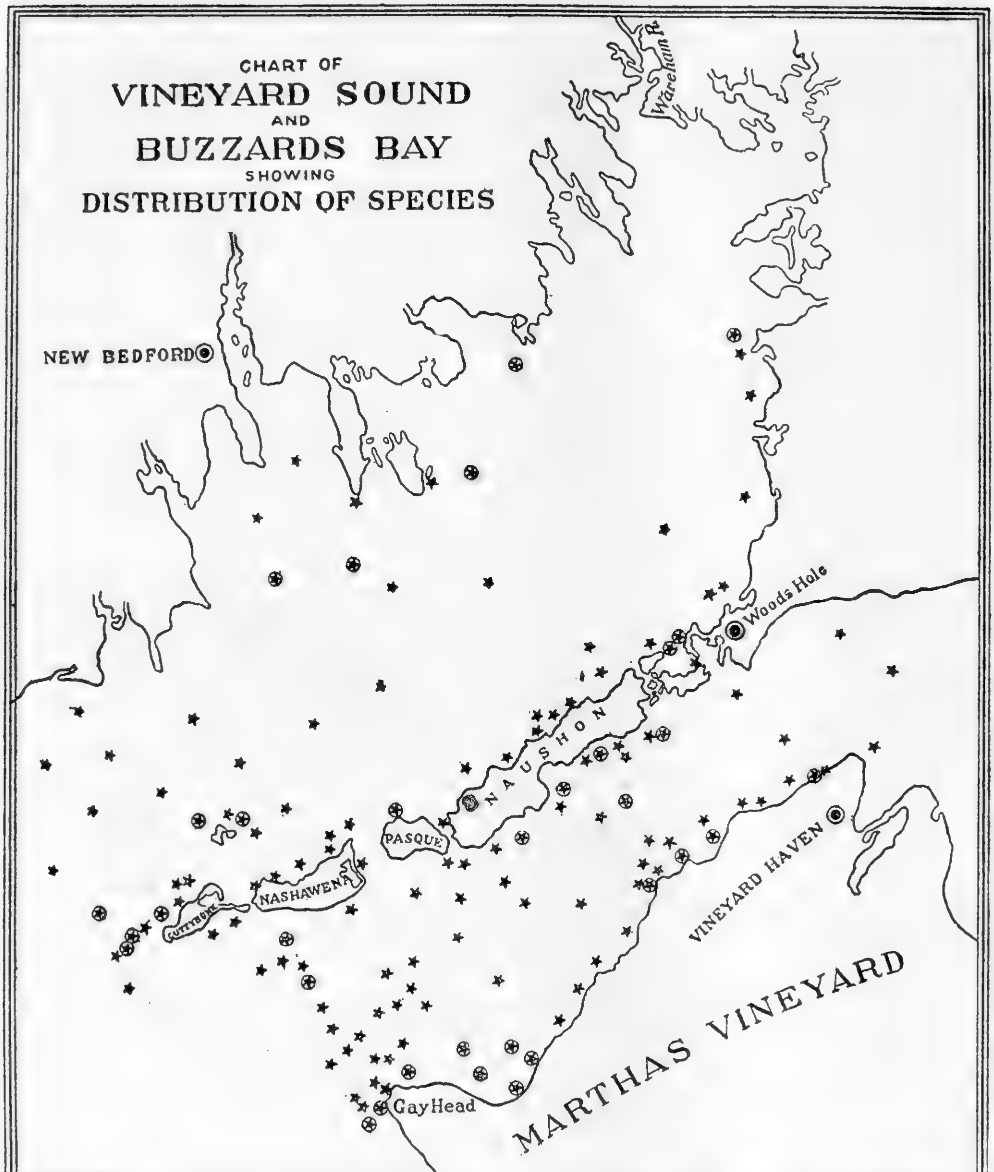


CHART 188.—Polynices triseriata. (See explanation of chart 26.)

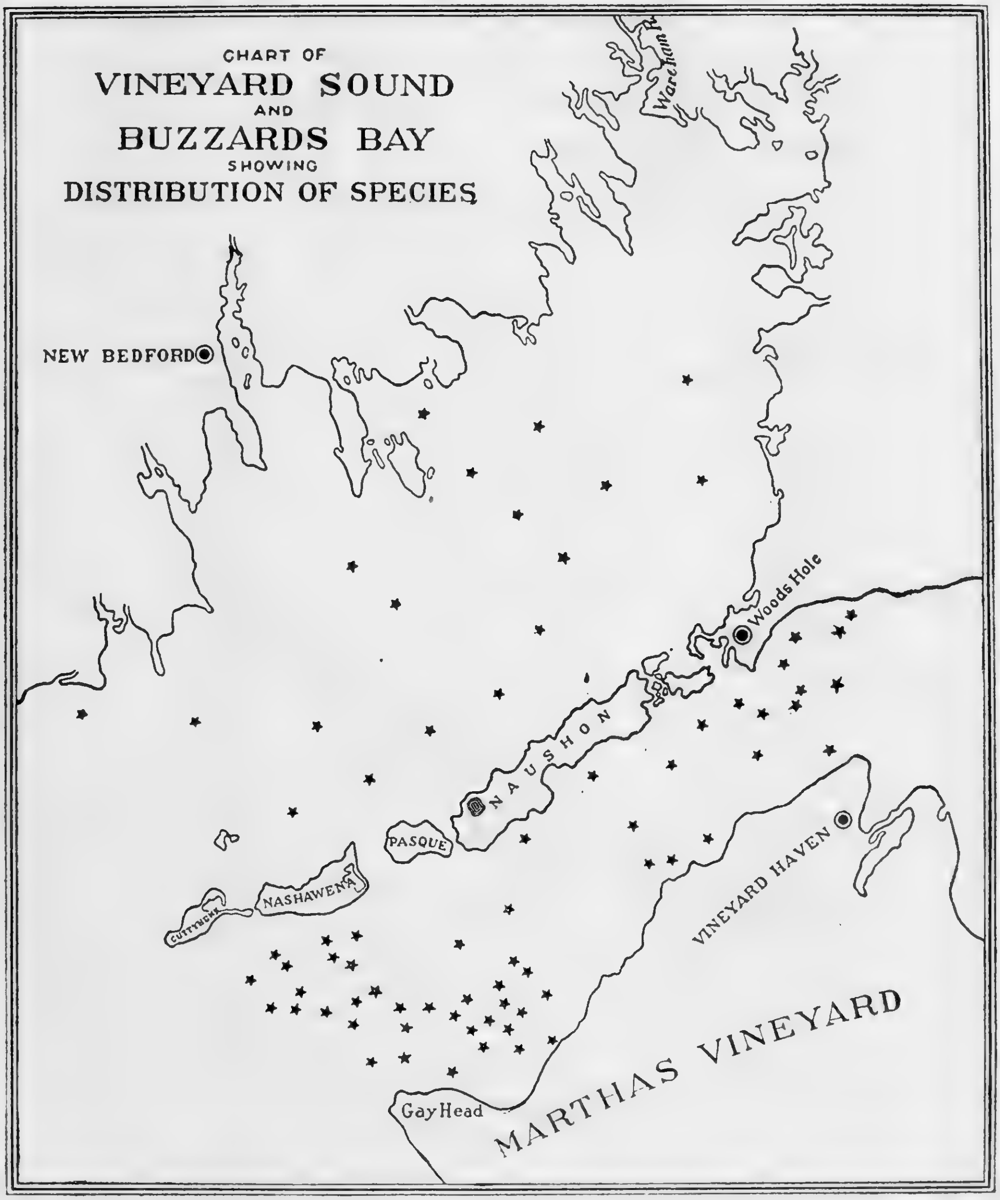


CHART 189.—Loligo pealii.

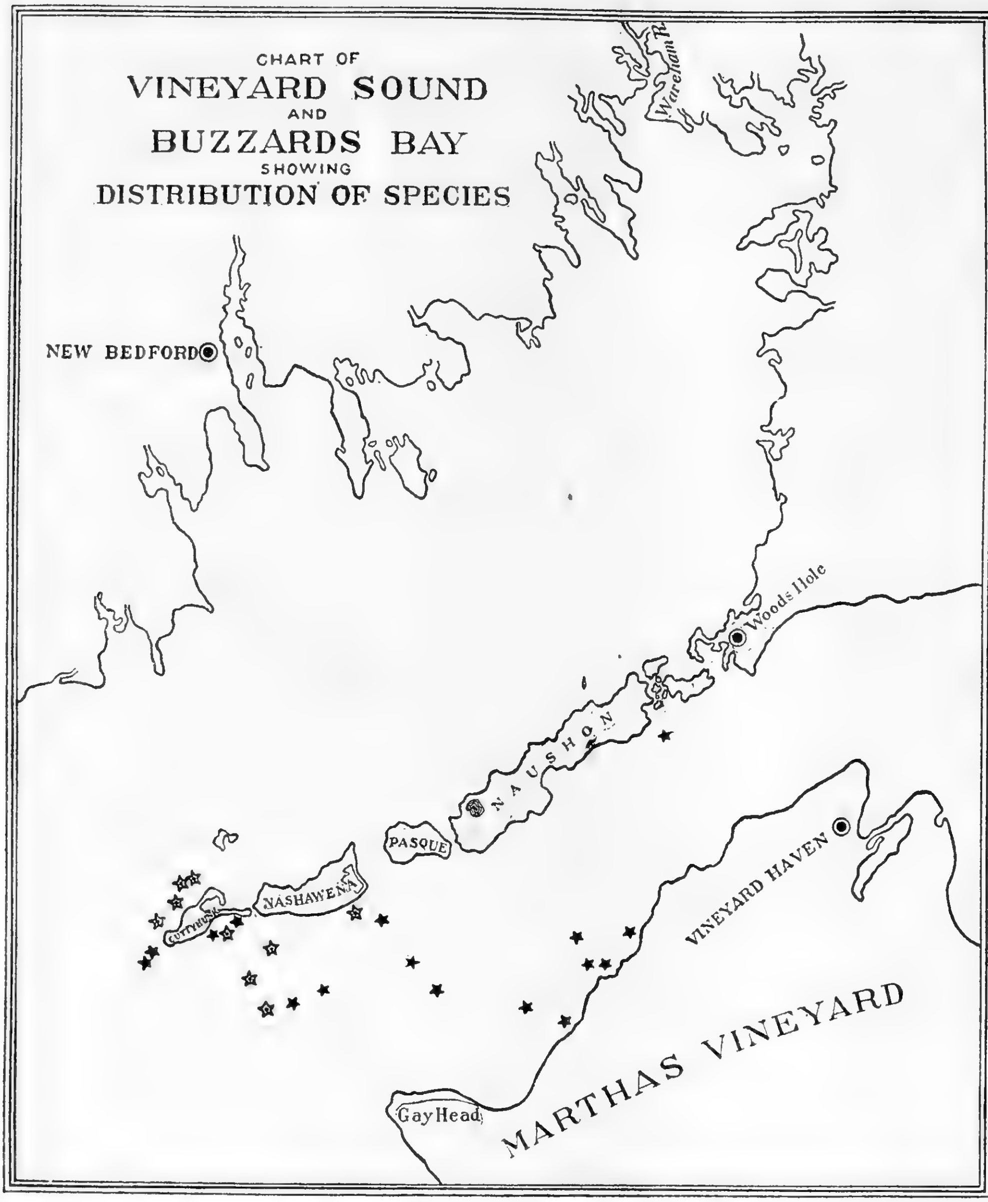


CHART 190.—Molgula arenata and Eugyra glutinans.

The stars of solid black denote those stations from which the first-named species was recorded, the dotted stars denoting those stations from which the second was recorded. Owing to the probability that these two species were in some cases confused, their occurrence has been plotted upon a single chart.

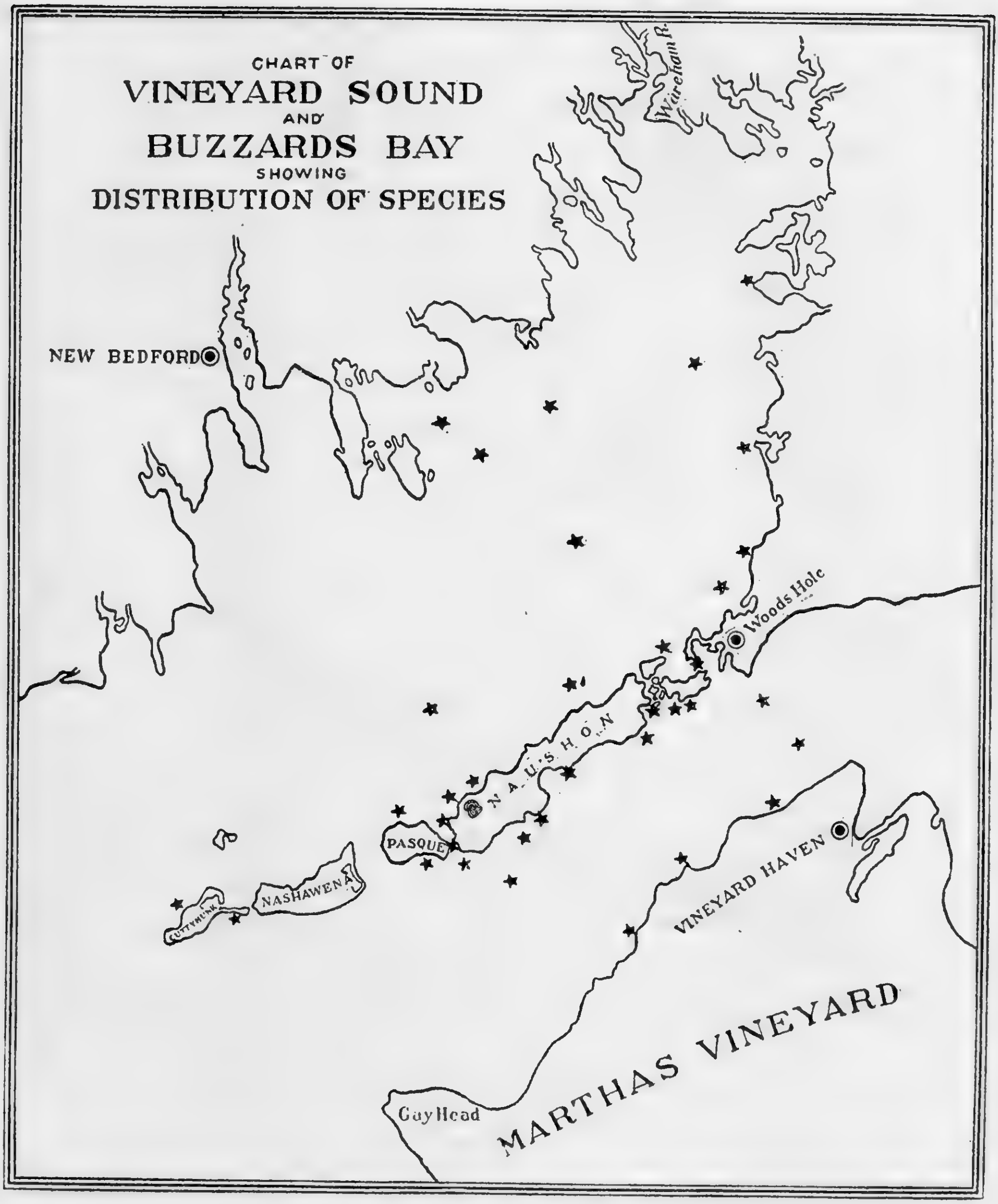


CHART 191.—Molgula manhattensis.

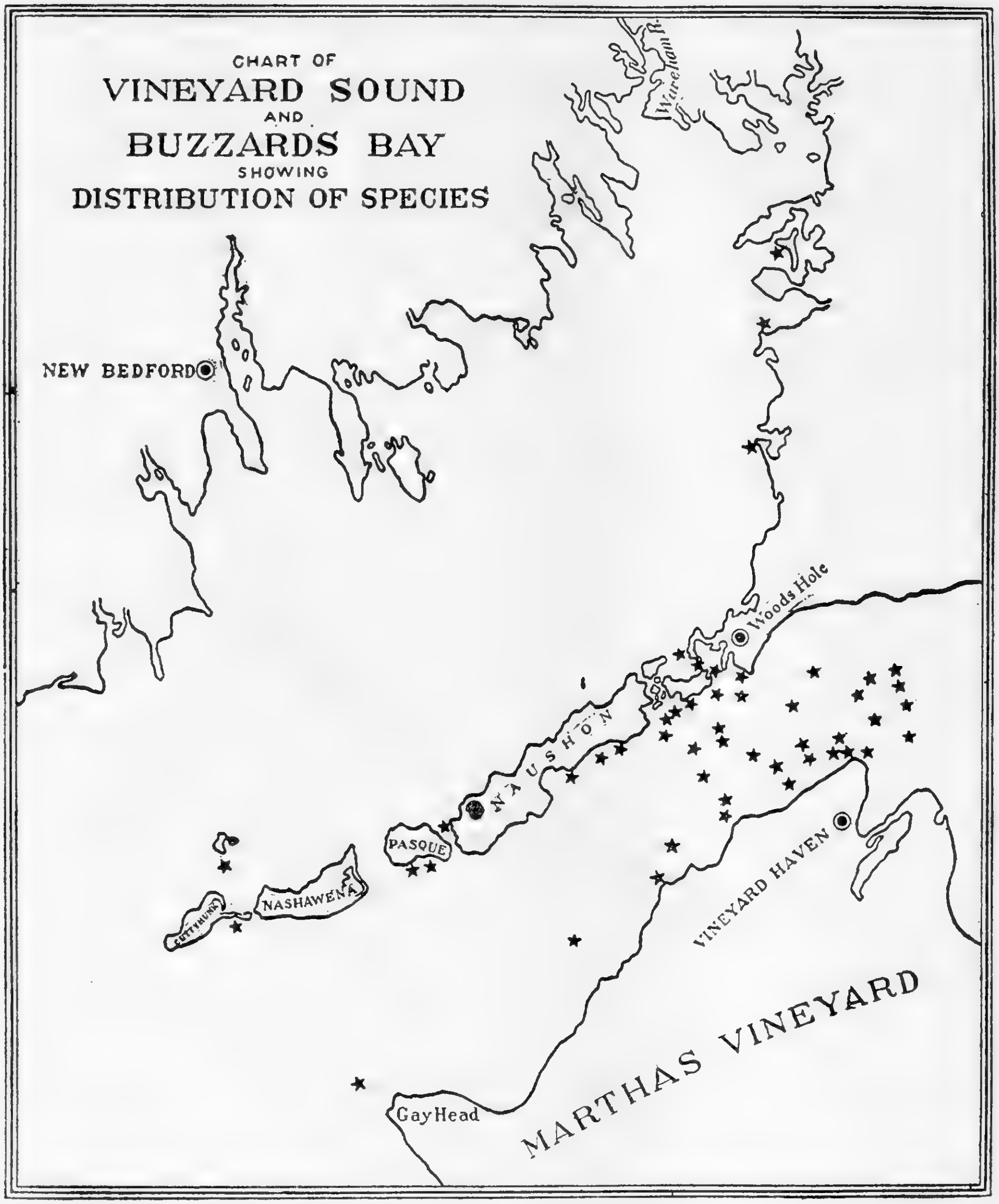


CHART 192.—Styela partita.

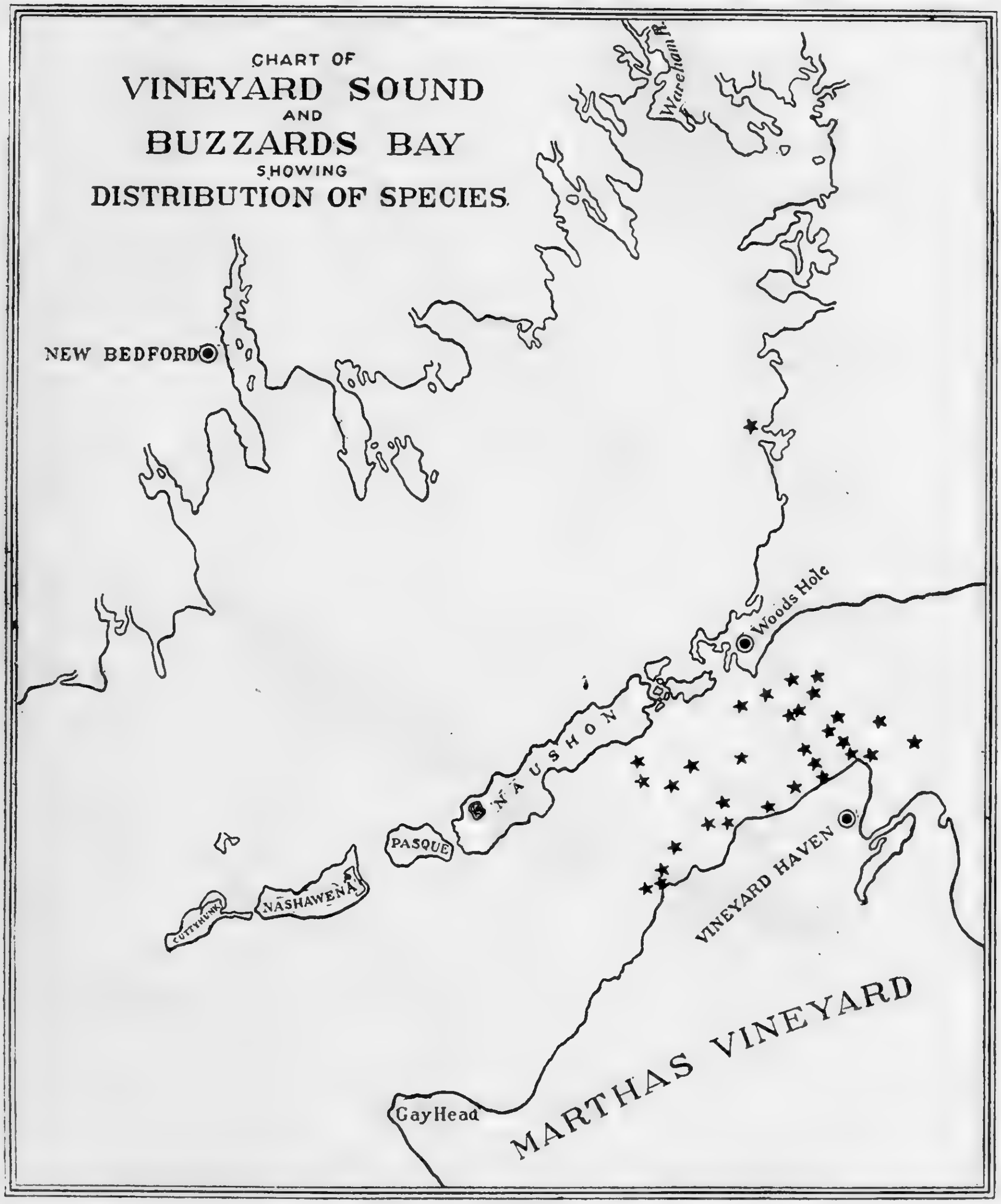


CHART 193.—Perophora viridis.

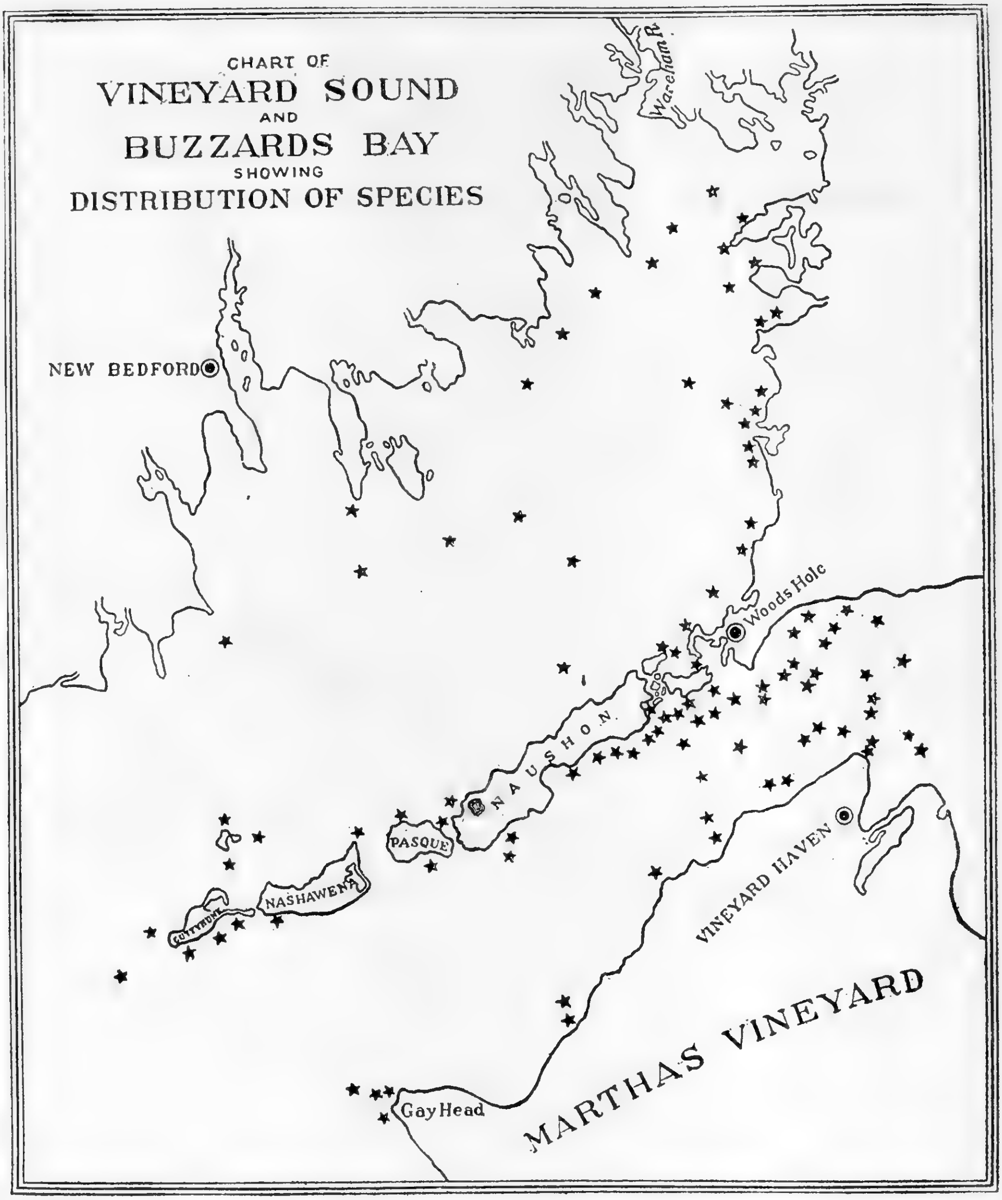


CHART 194.—Didemnum lutarium.

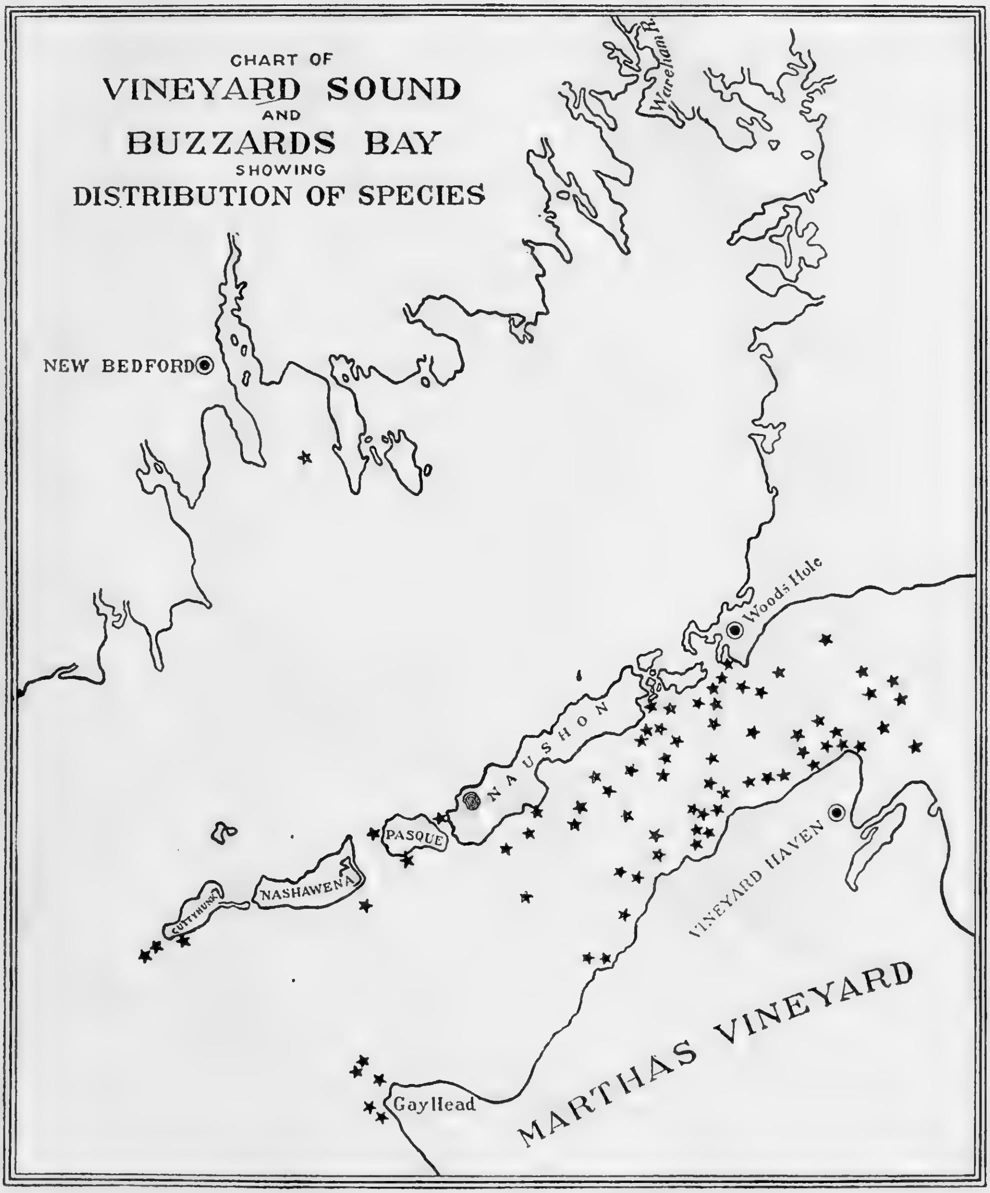


CHART 195.—Amaroucium pellucidum.

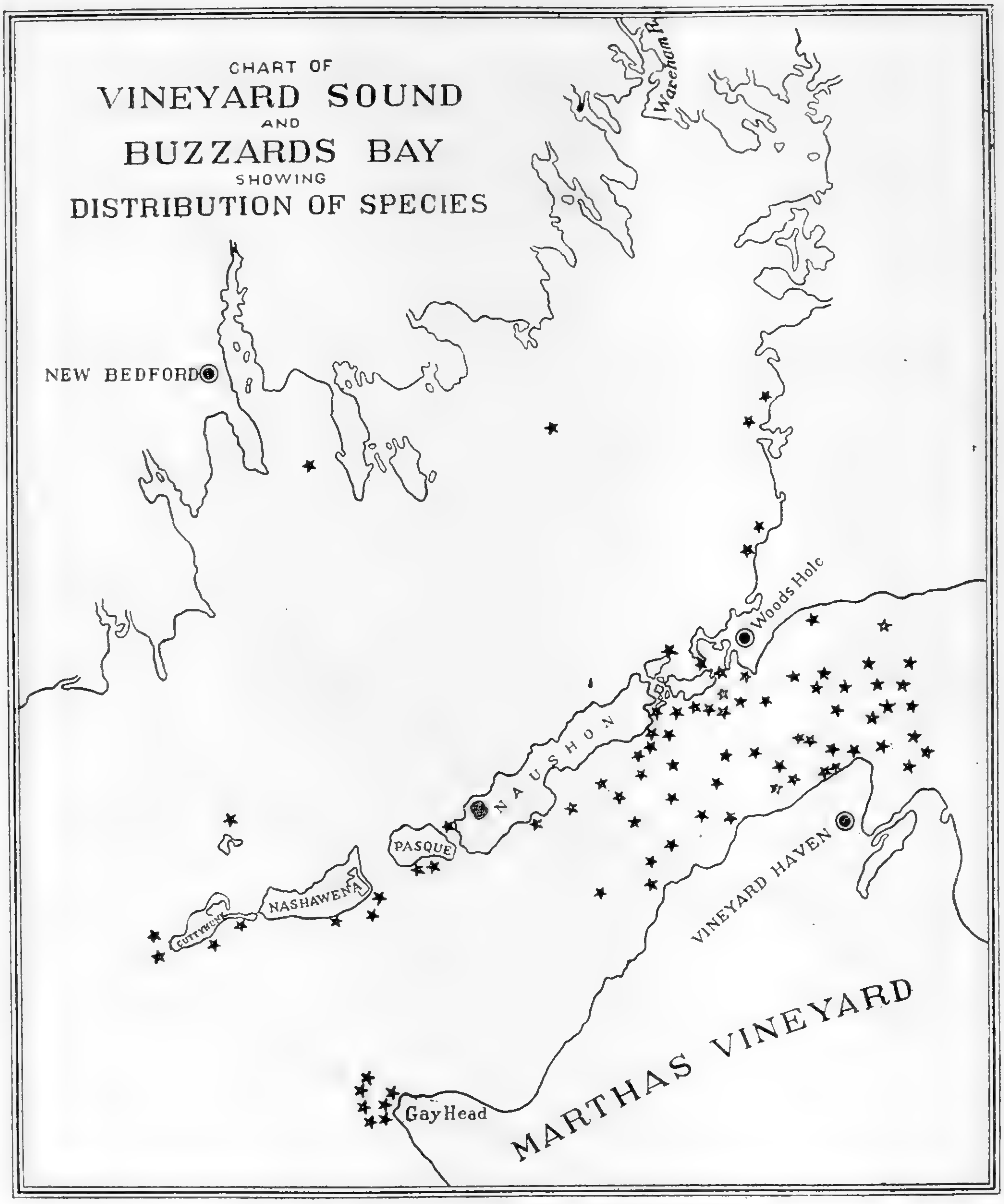


CHART 196.—Amaroucium pellucidum constellatum.

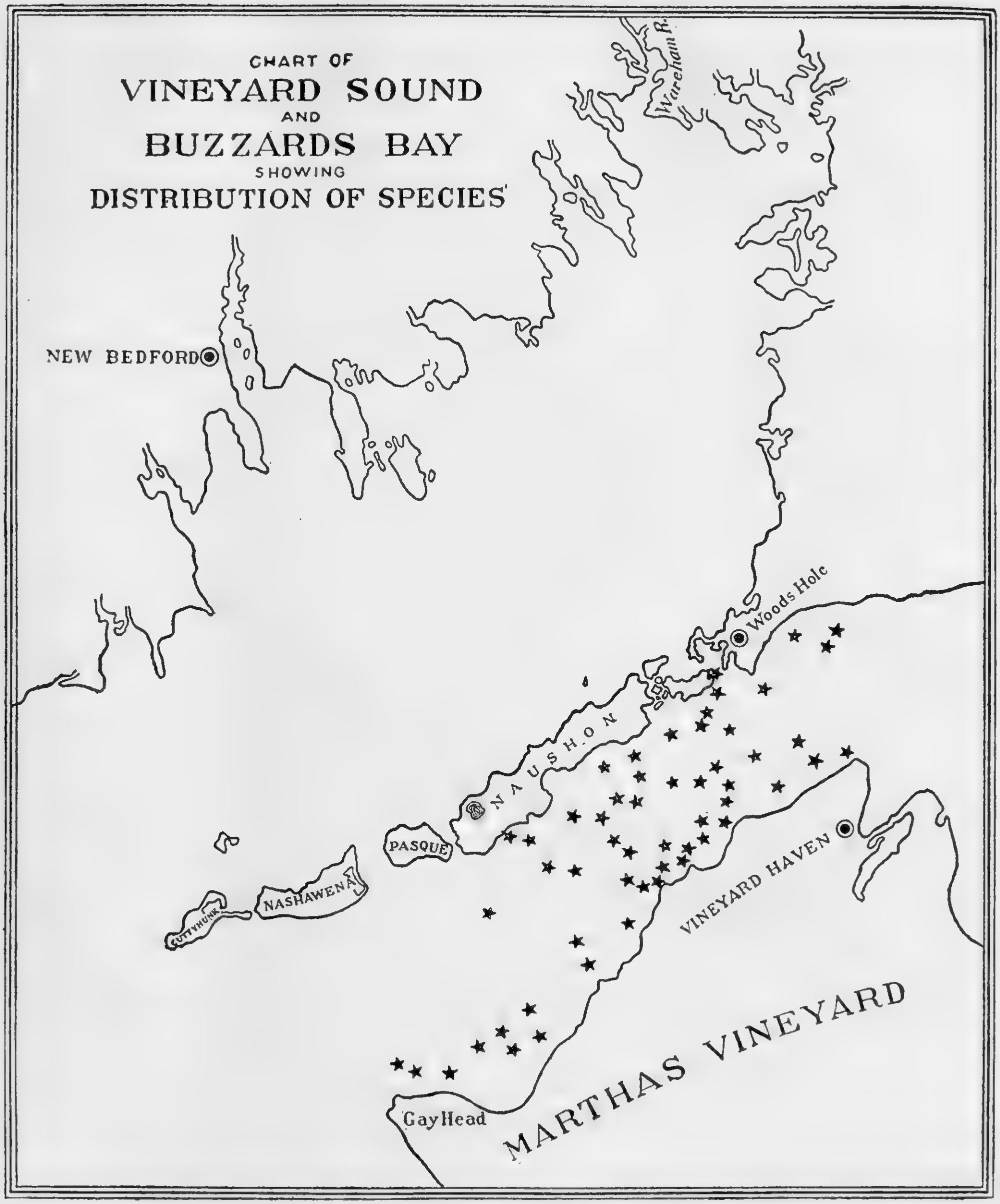


CHART 197.—Amaroucium stellatum.

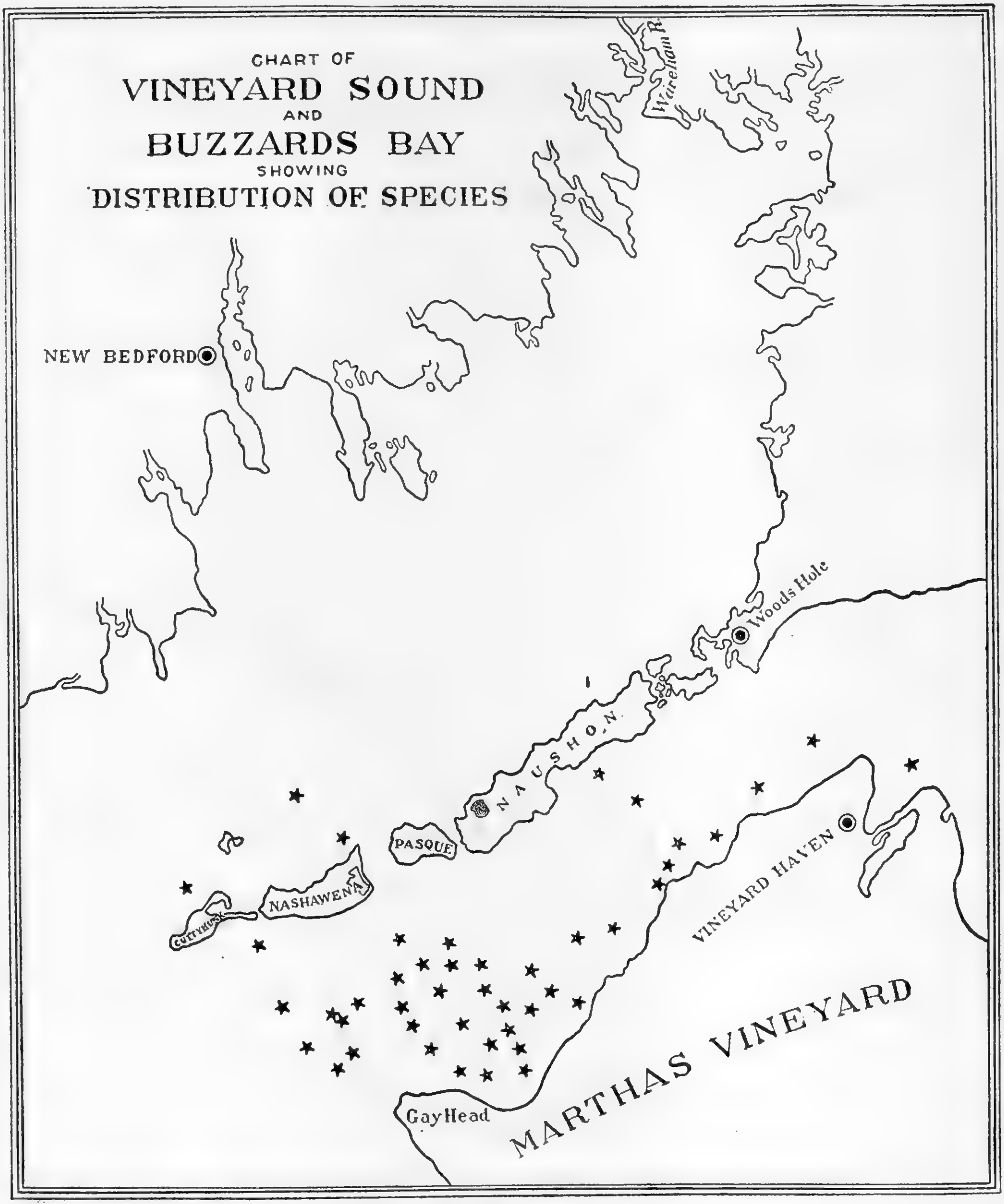


CHART 198.—Raja erinacea.

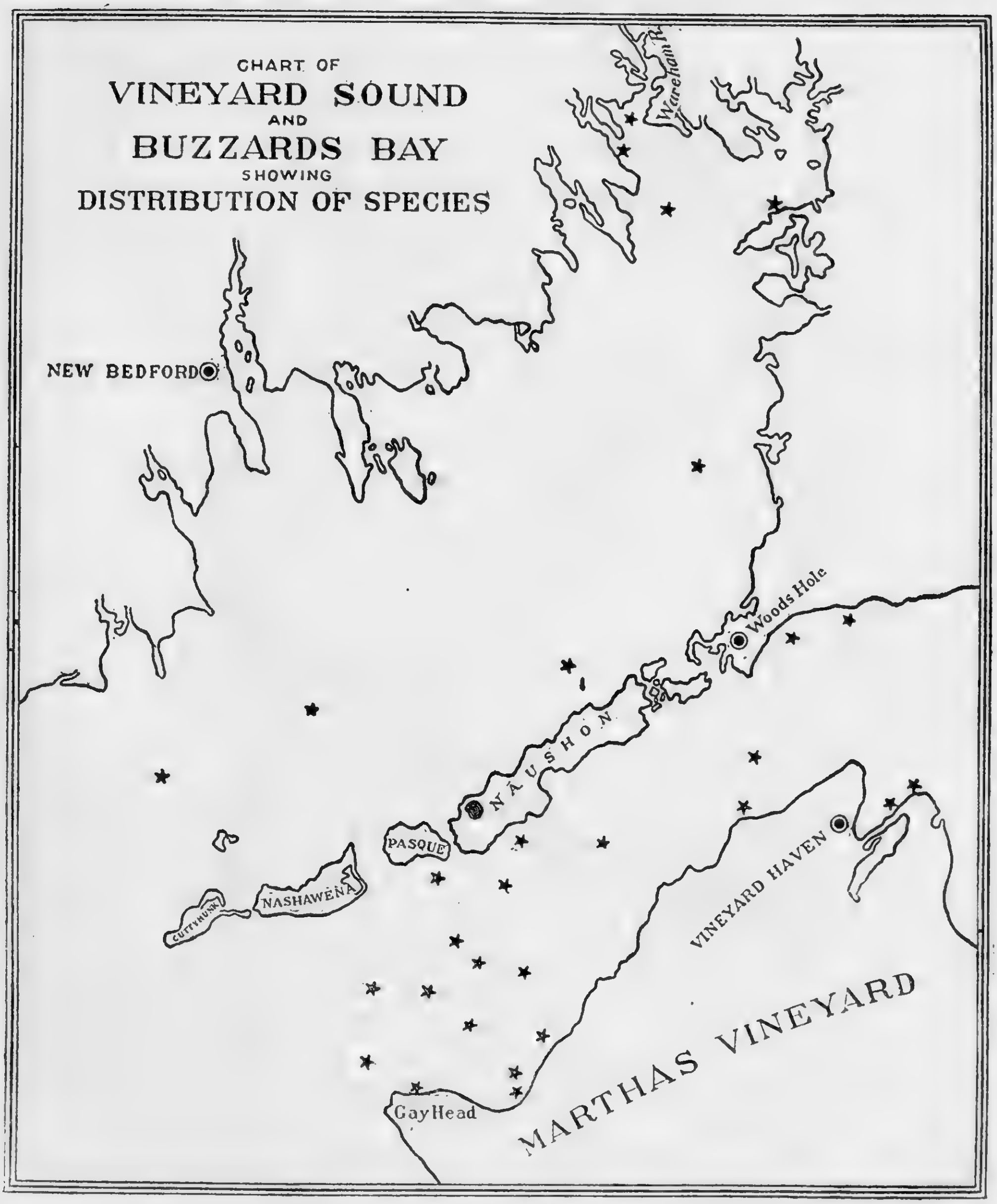


CHART 199.—Syngnathus fuscus.

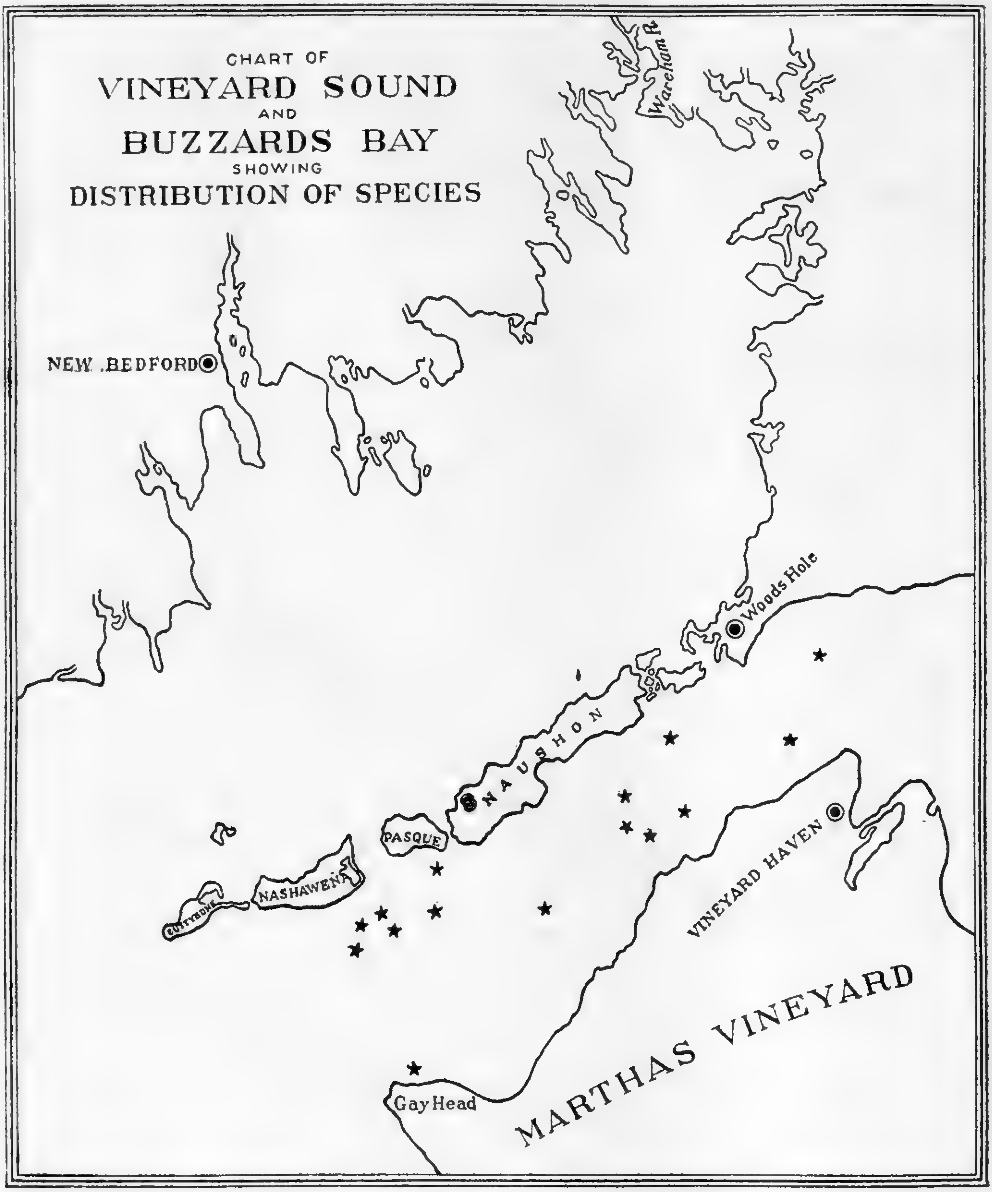


CHART 200.—Ammodytes americanus.

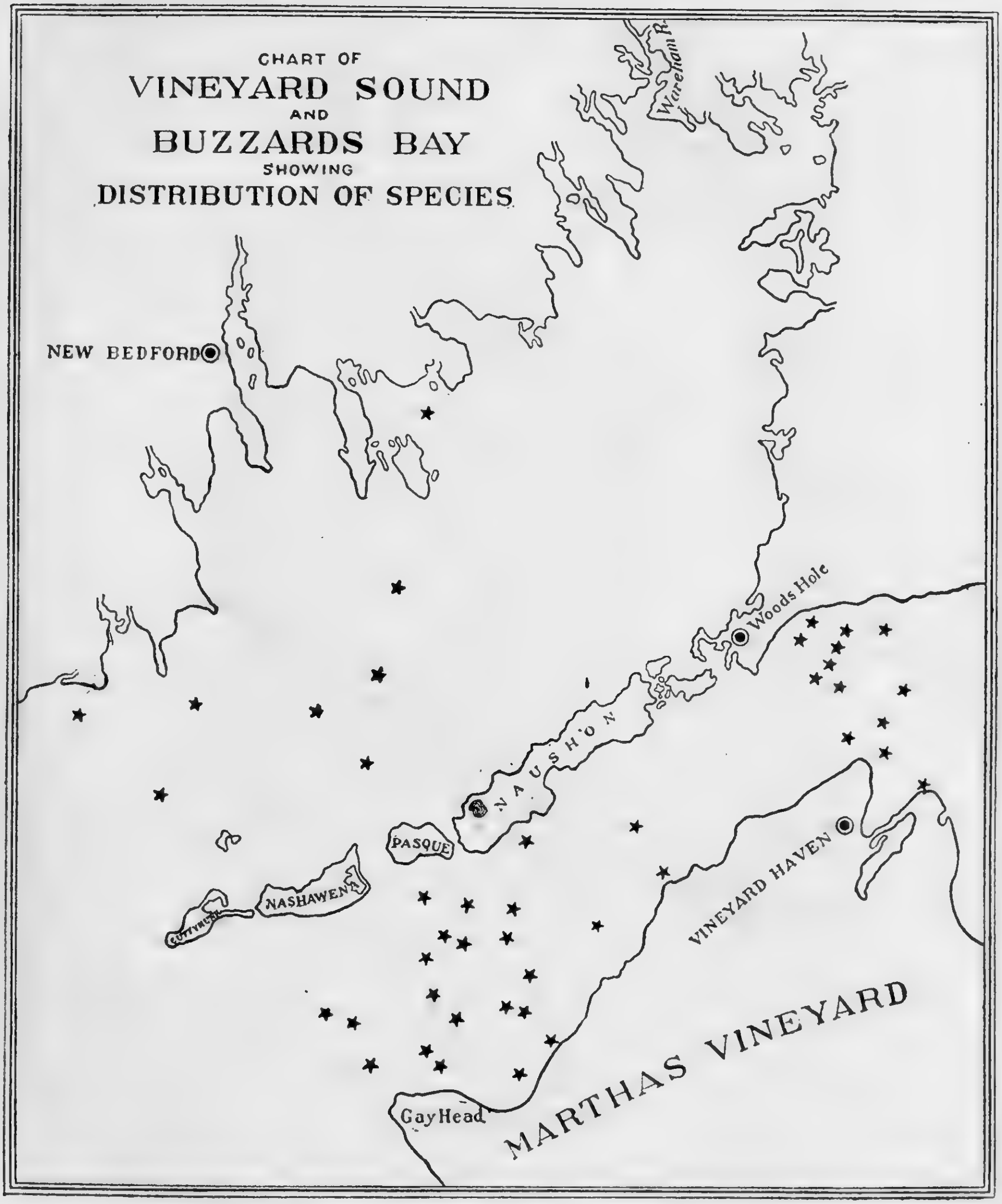


CHART 201.—Stenotomus chrysops.

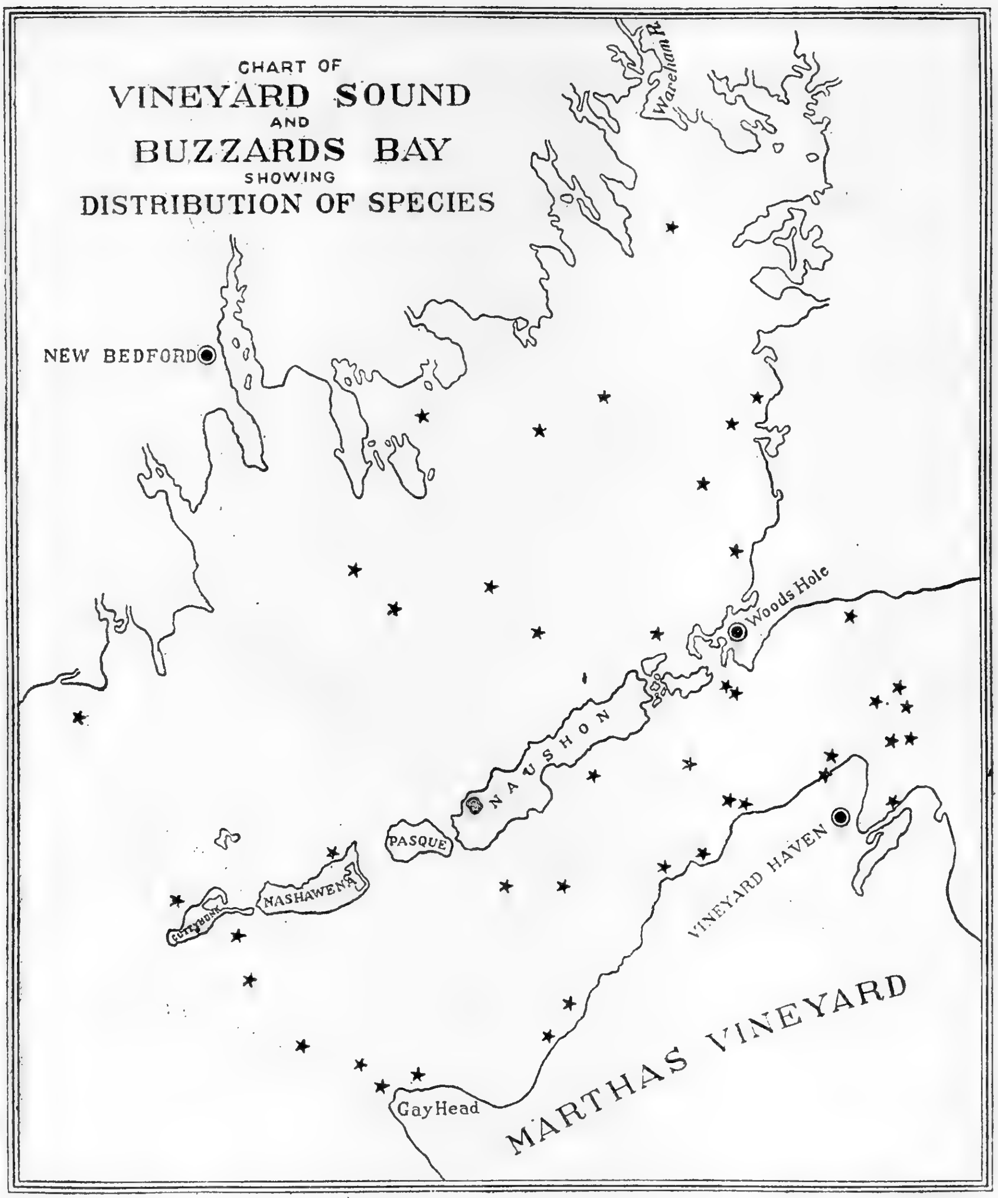


CHART 202.—Tautogolabrus adspersus.

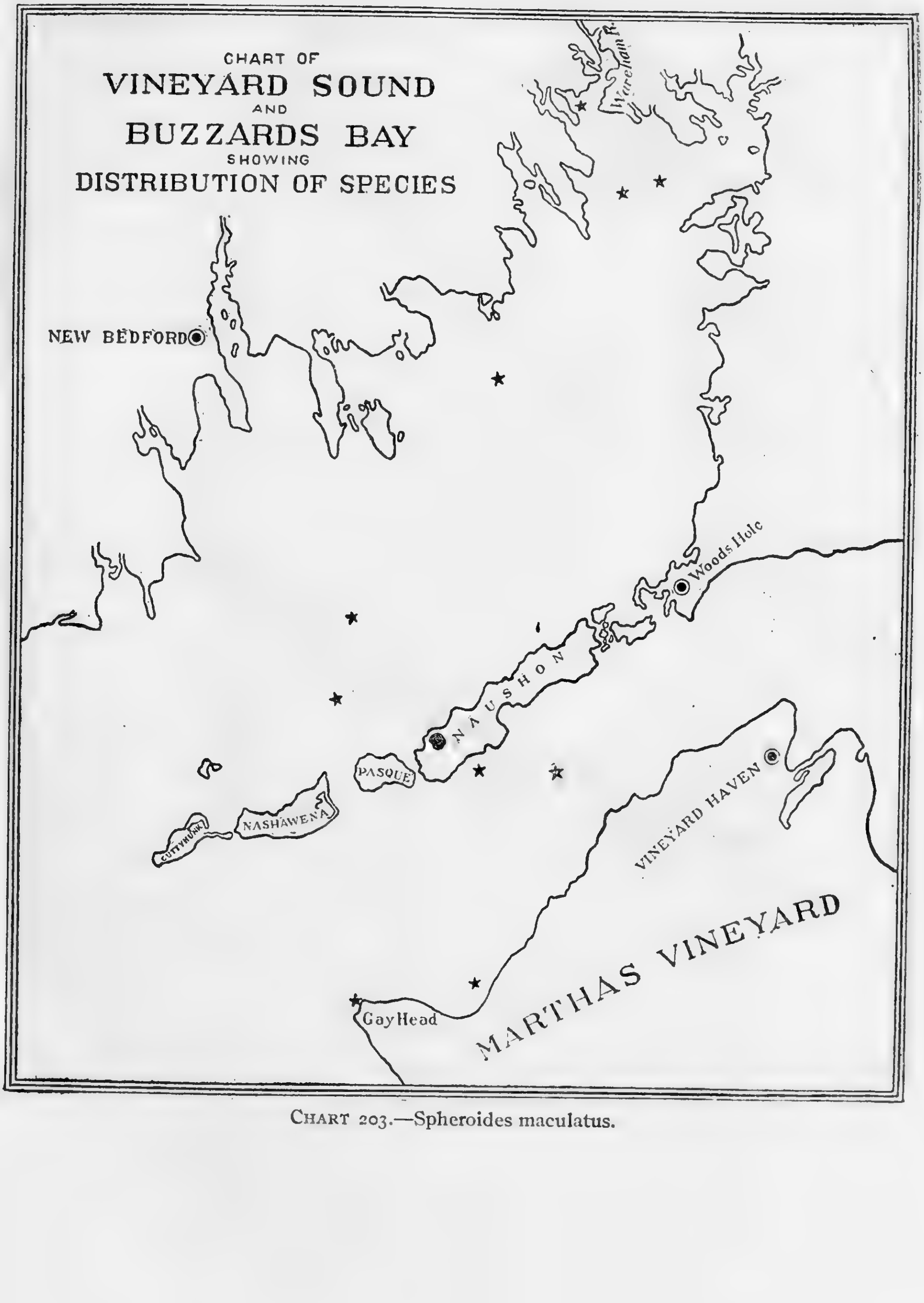


CHART 203.—Spheroides maculatus.

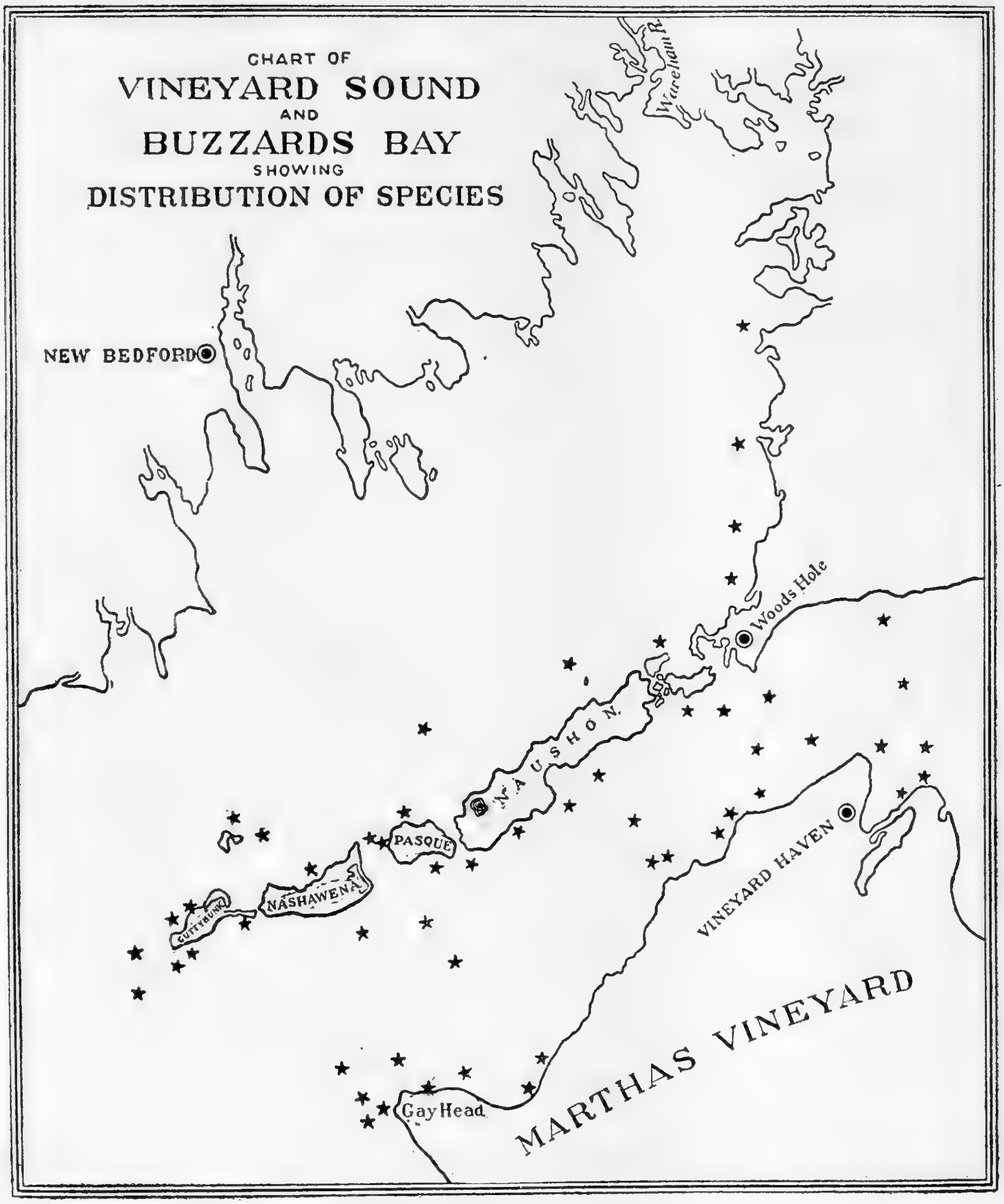


CHART 204.—Myoxocephalus æneus.

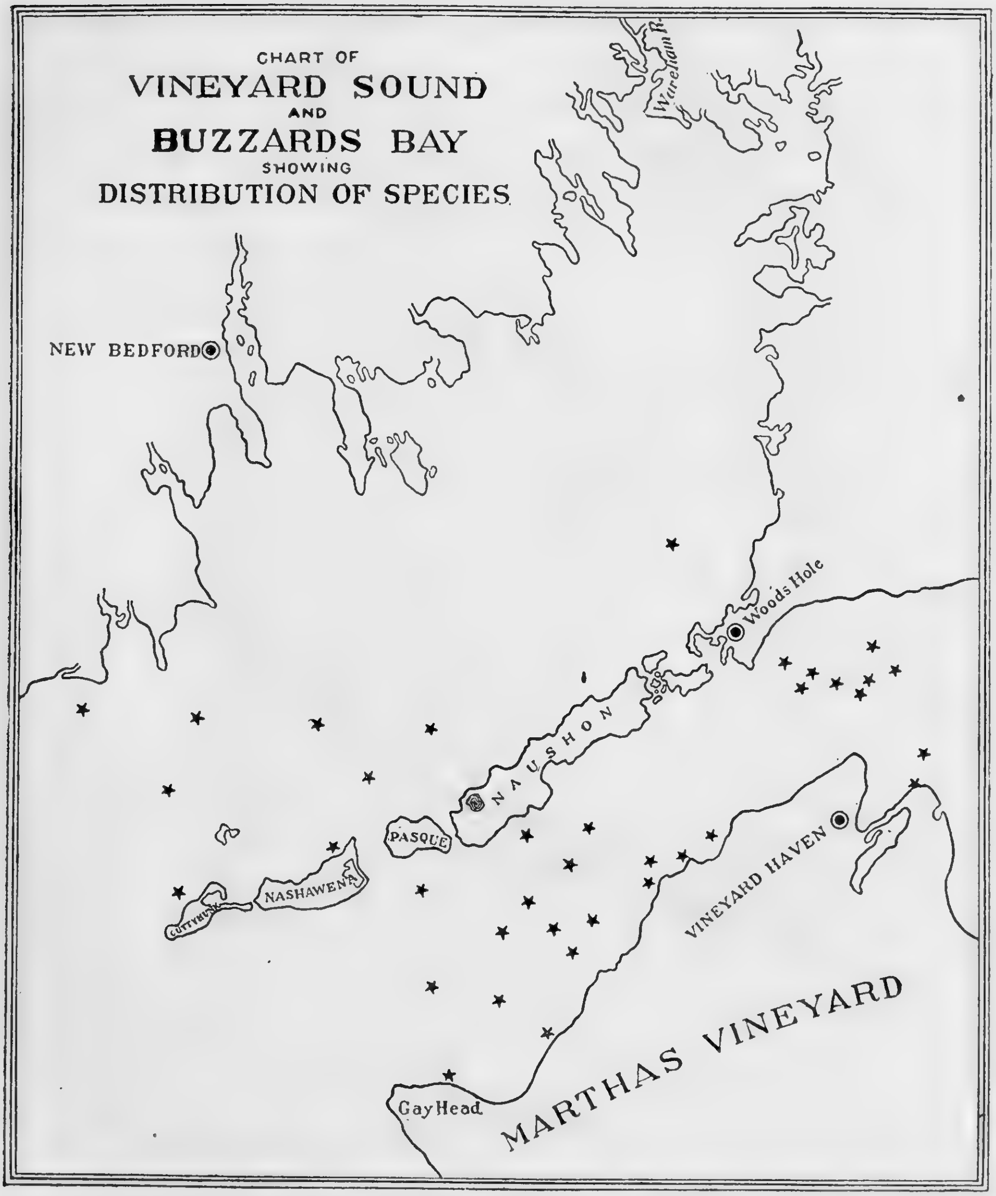


CHART 205.—Prionotus carolinus.

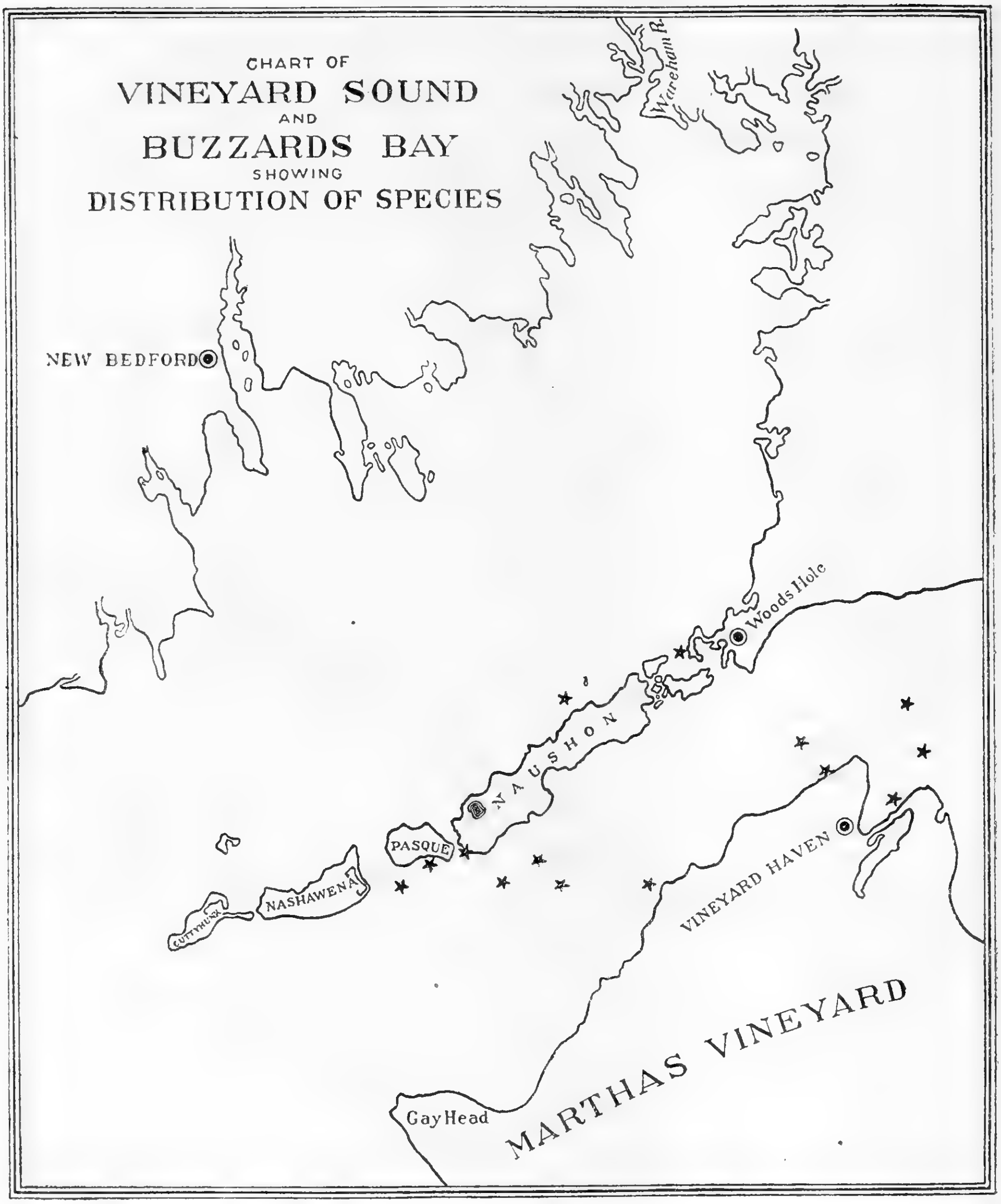


CHART 206.—Pholis gunellus.

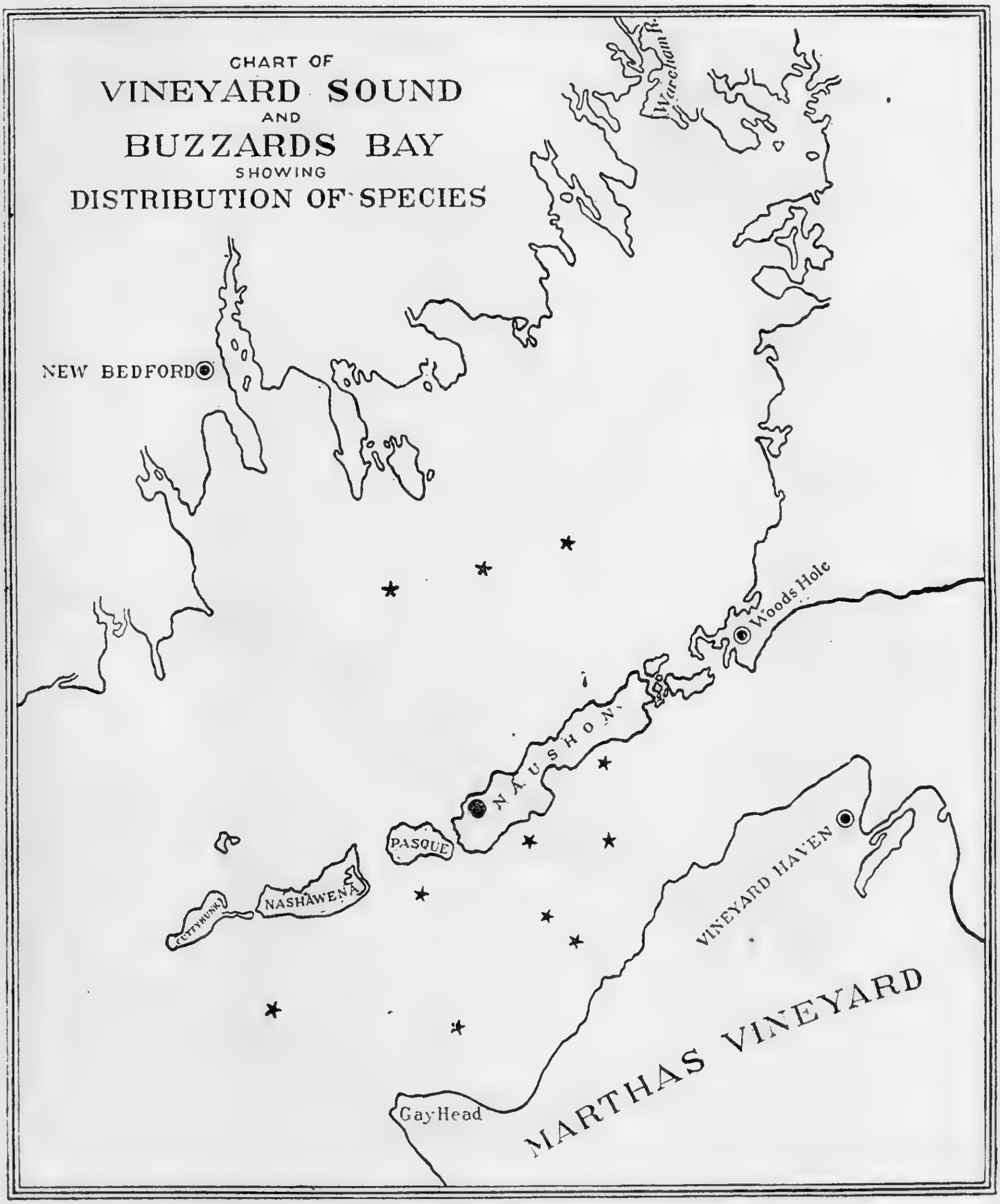


CHART 207.—Paralichthys dentatus.

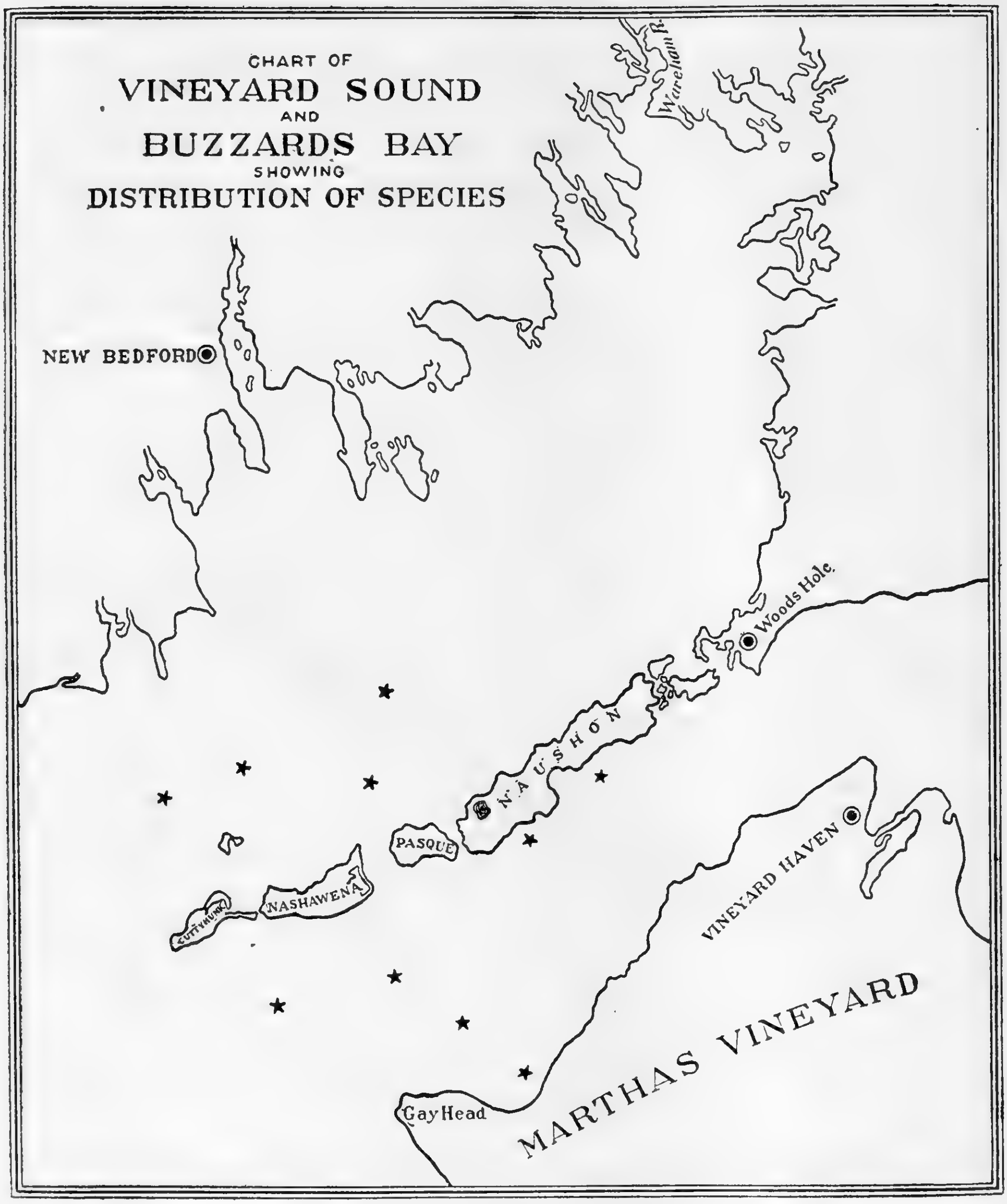


CHART 208.—Paralichthys oblongus.

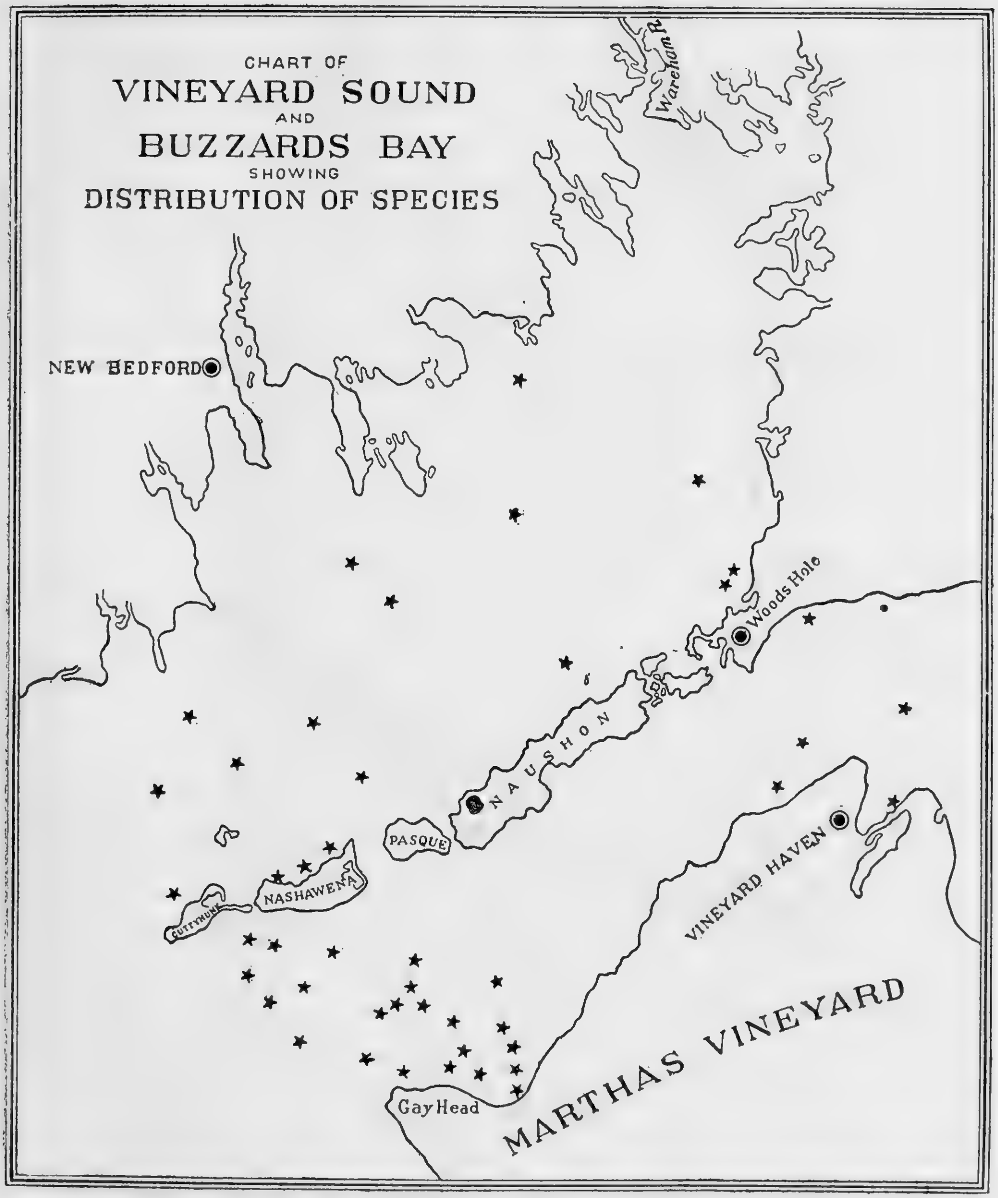


CHART 209.—Pseudopleuronectes americanus.

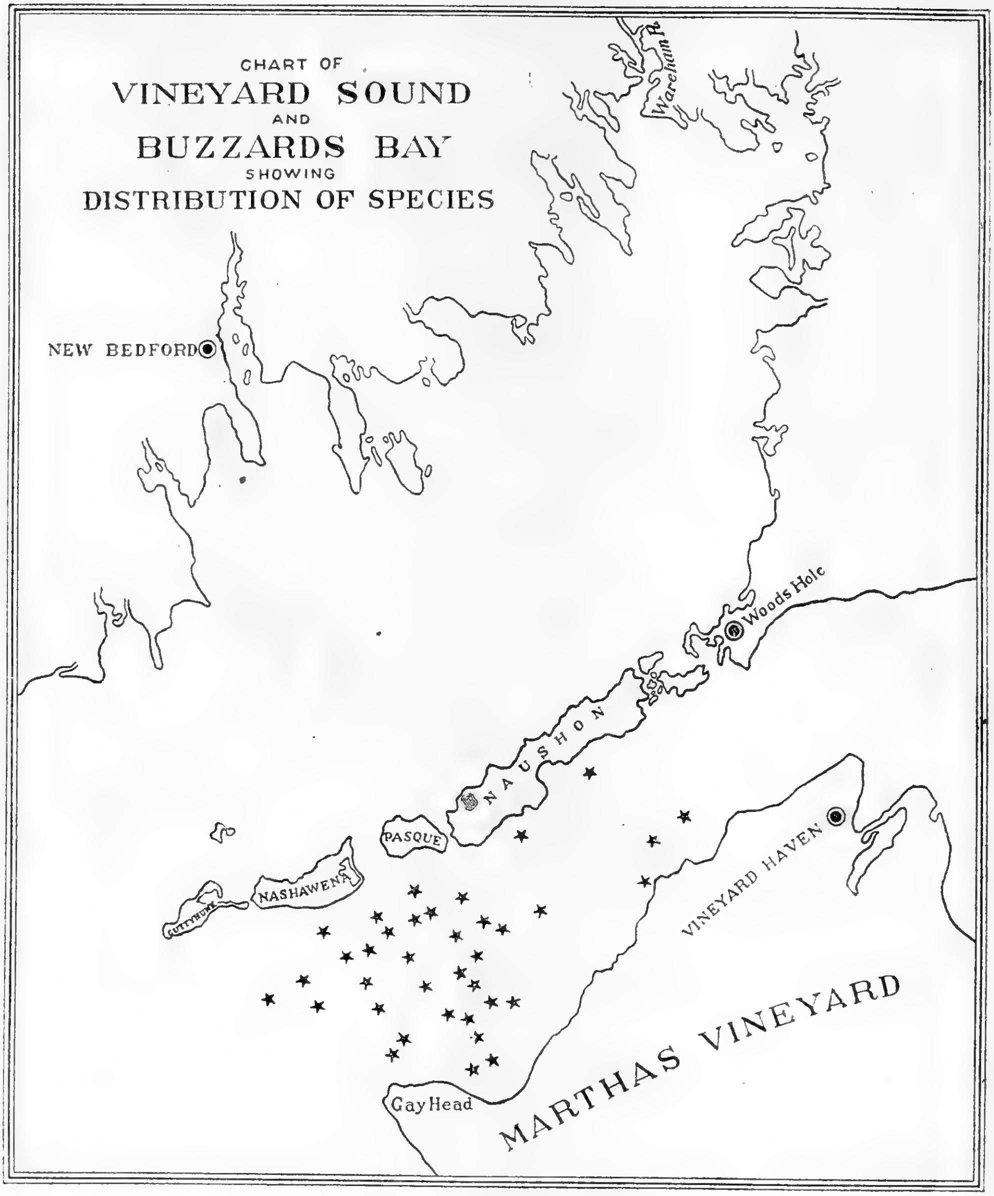


CHART 210.—Lophopsetta maculata.

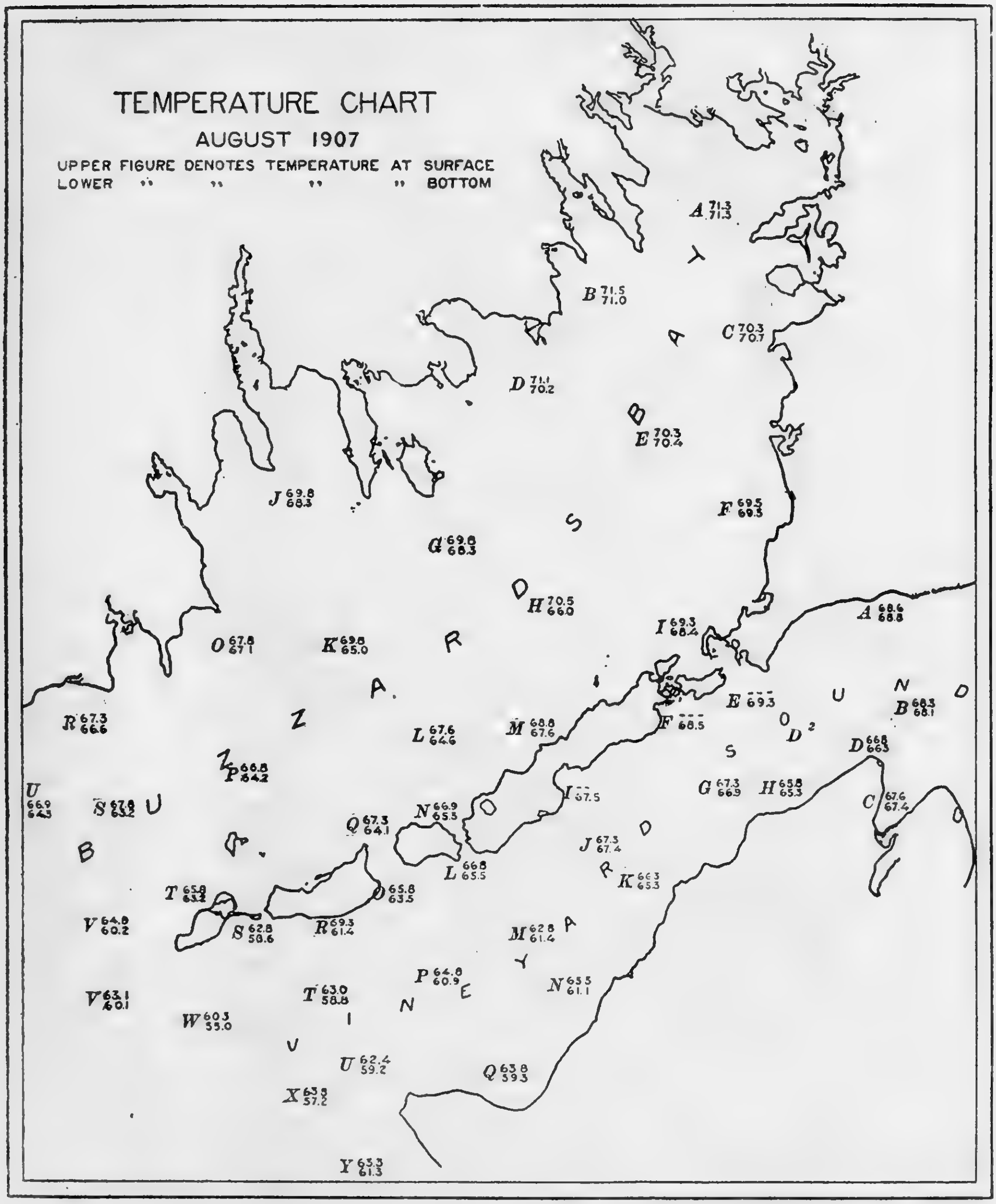


CHART 211.—Temperature throughout Buzzards Bay and Vineyard Sound, August, 1907.

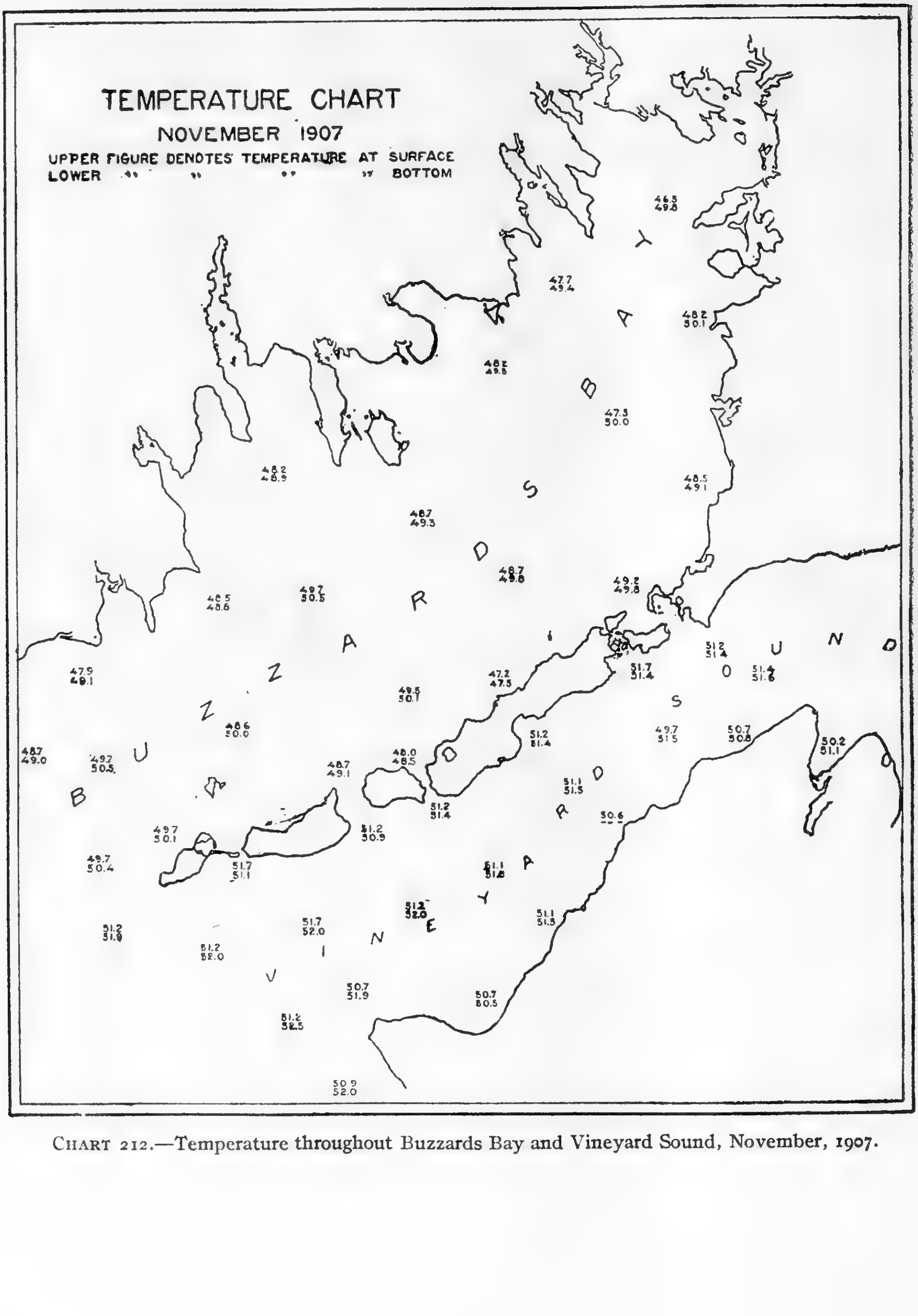


CHART 212.—Temperature throughout Buzzards Bay and Vineyard Sound, November, 1907.

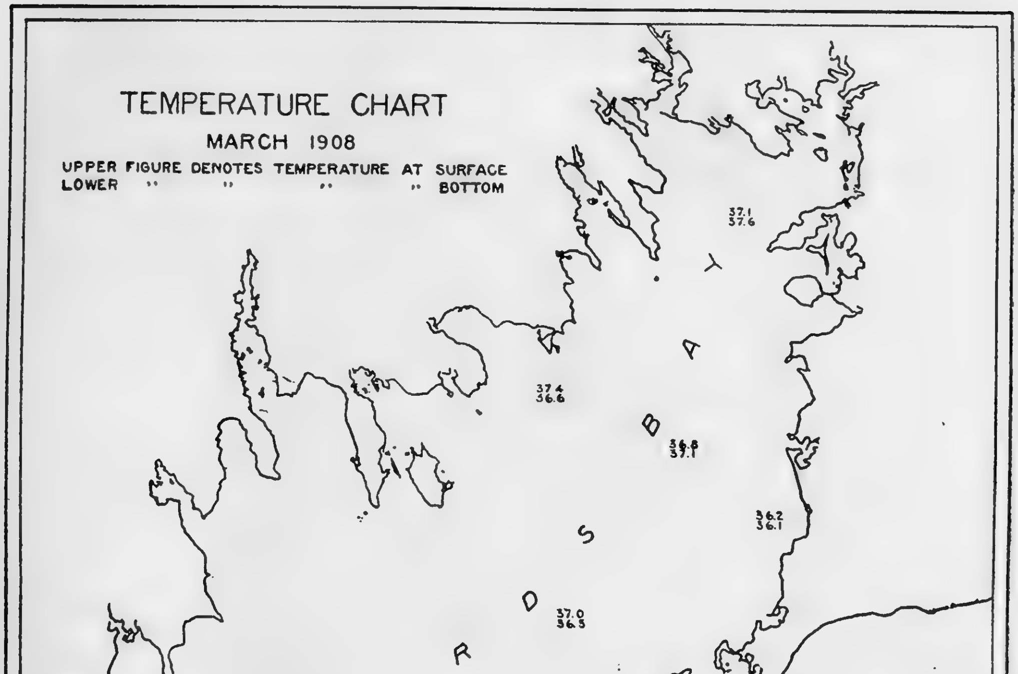


CHART 213.—Temperature throughout Buzzards Bay and Vineyard Sound, March, 1908.

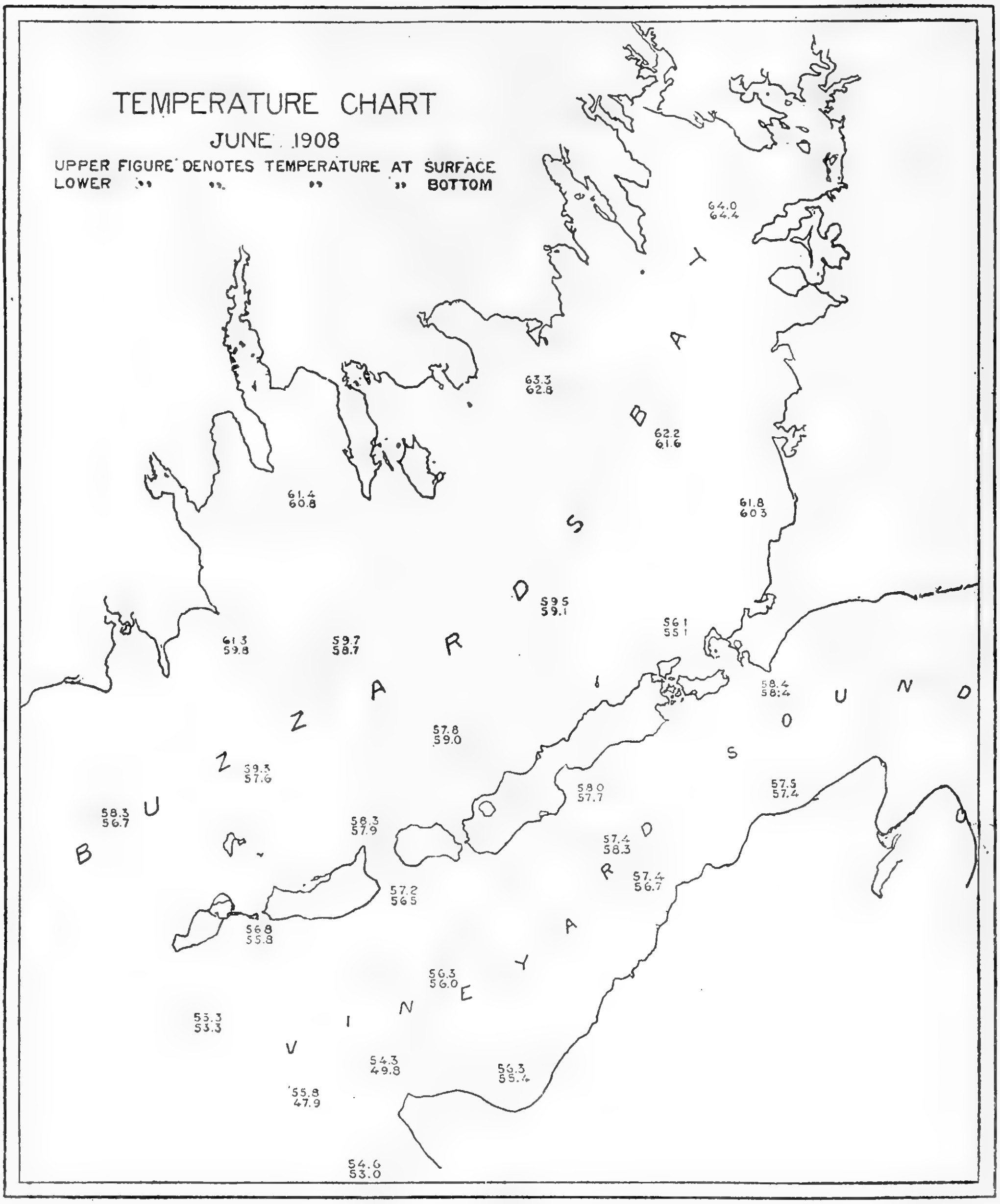


CHART 214.—Temperature throughout Buzzards Bay and Vineyard Sound, June, 1908.

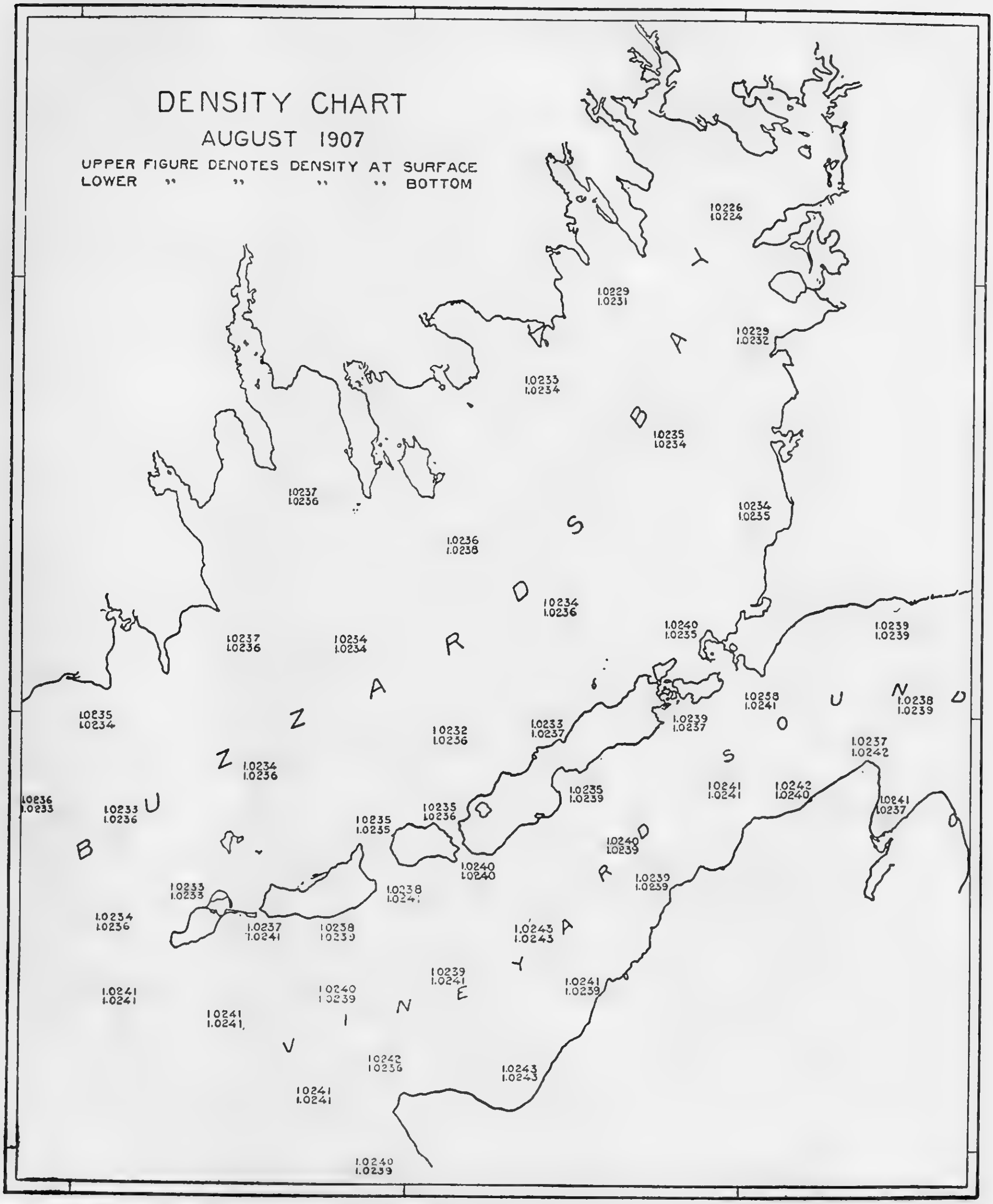


CHART 215.—Density throughout Buzzards Bay and Vineyard Sound, August, 1907.

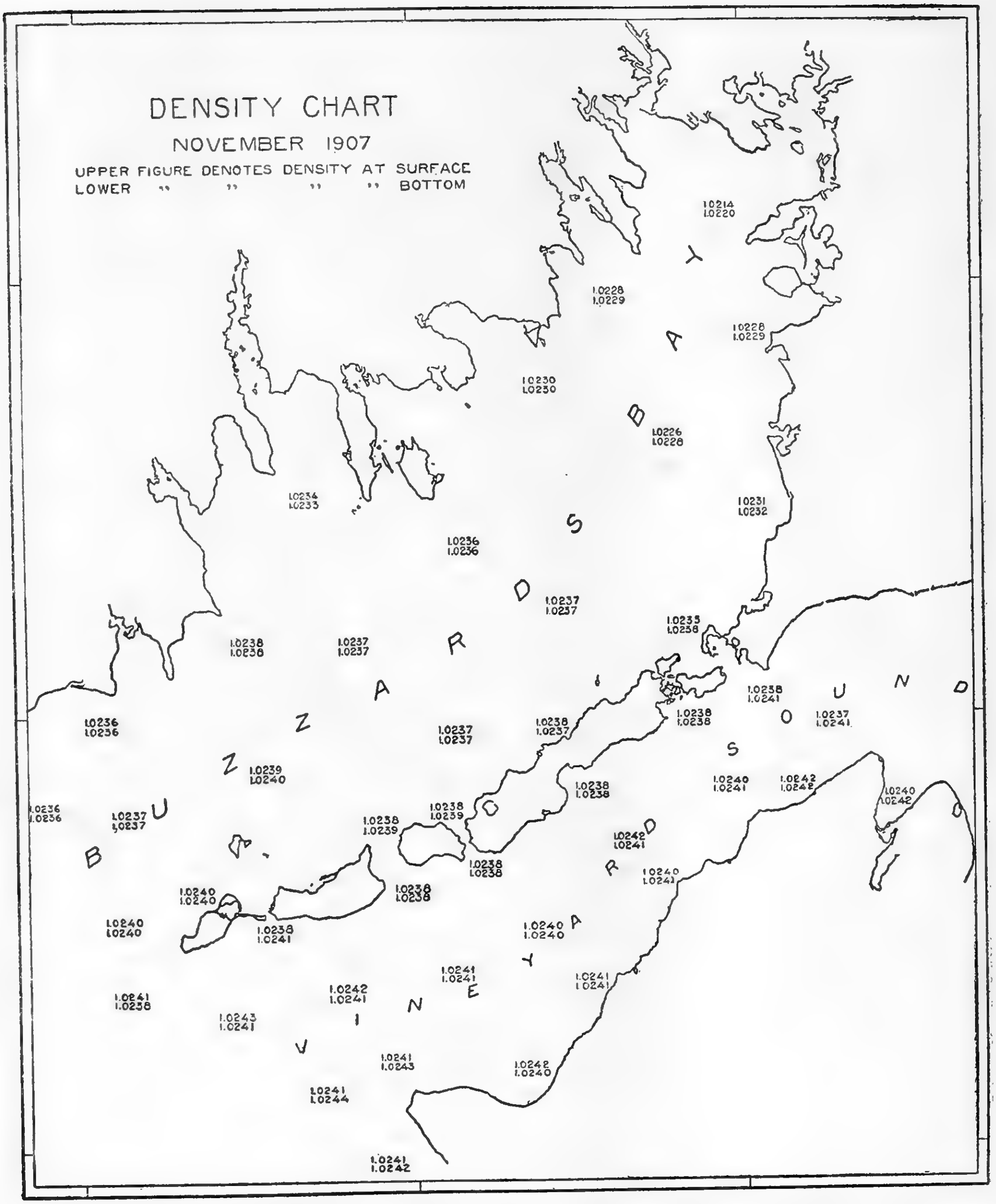


CHART 216.—Density throughout Buzzards Bay and Vineyard Sound, November, 1907.

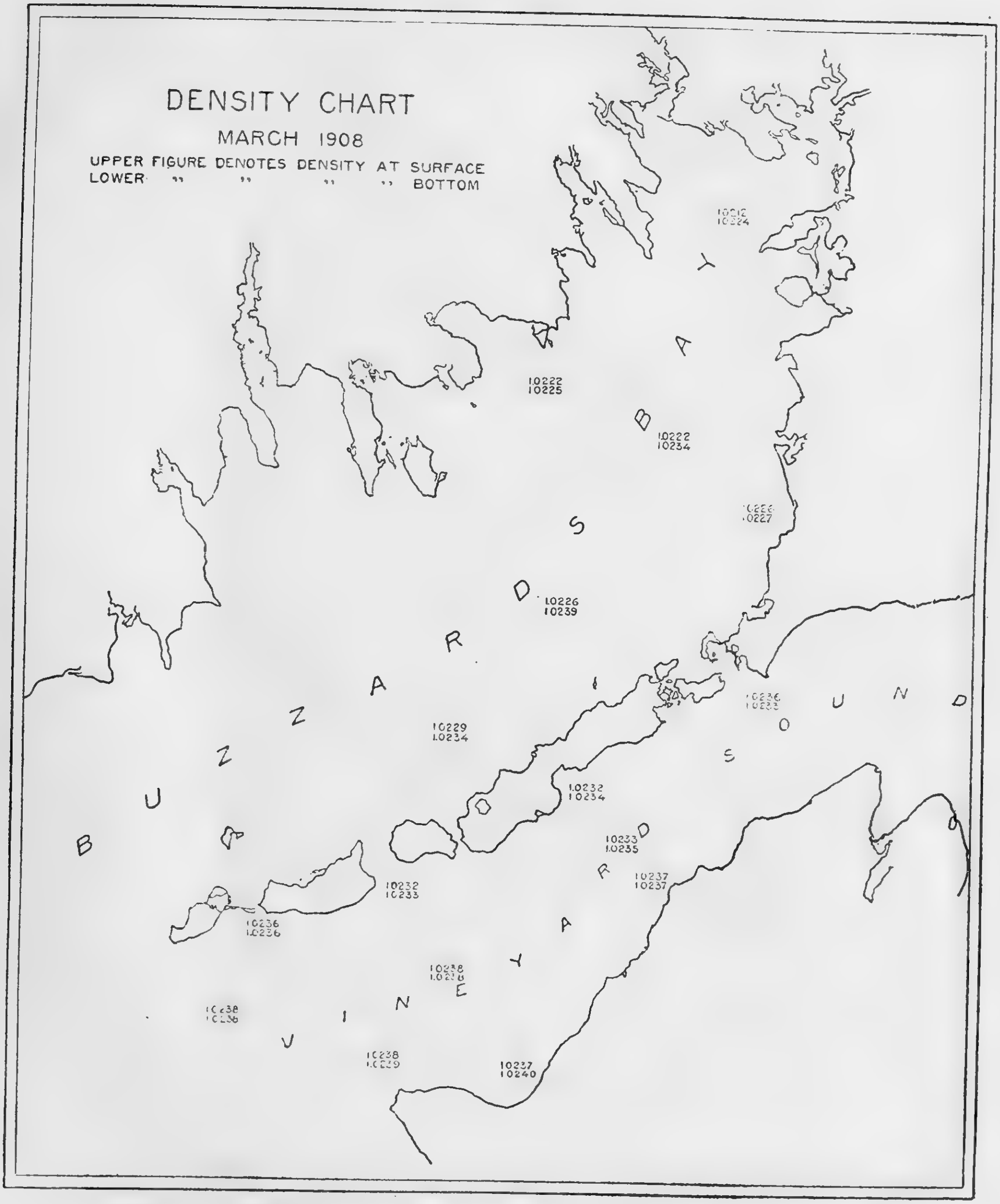


CHART 217.—Density throughout Buzzards Bay and Vineyard Sound, March, 1908.

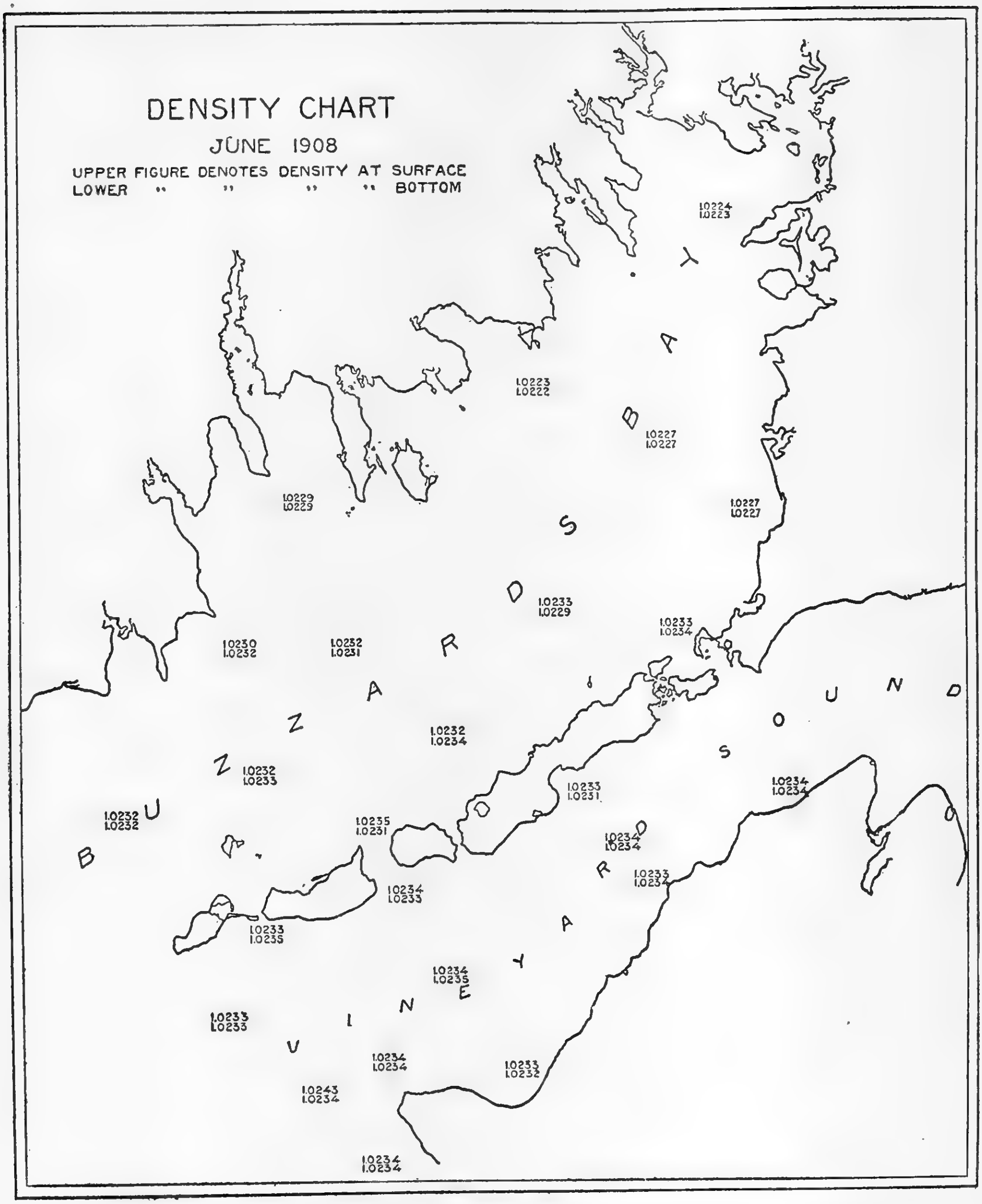
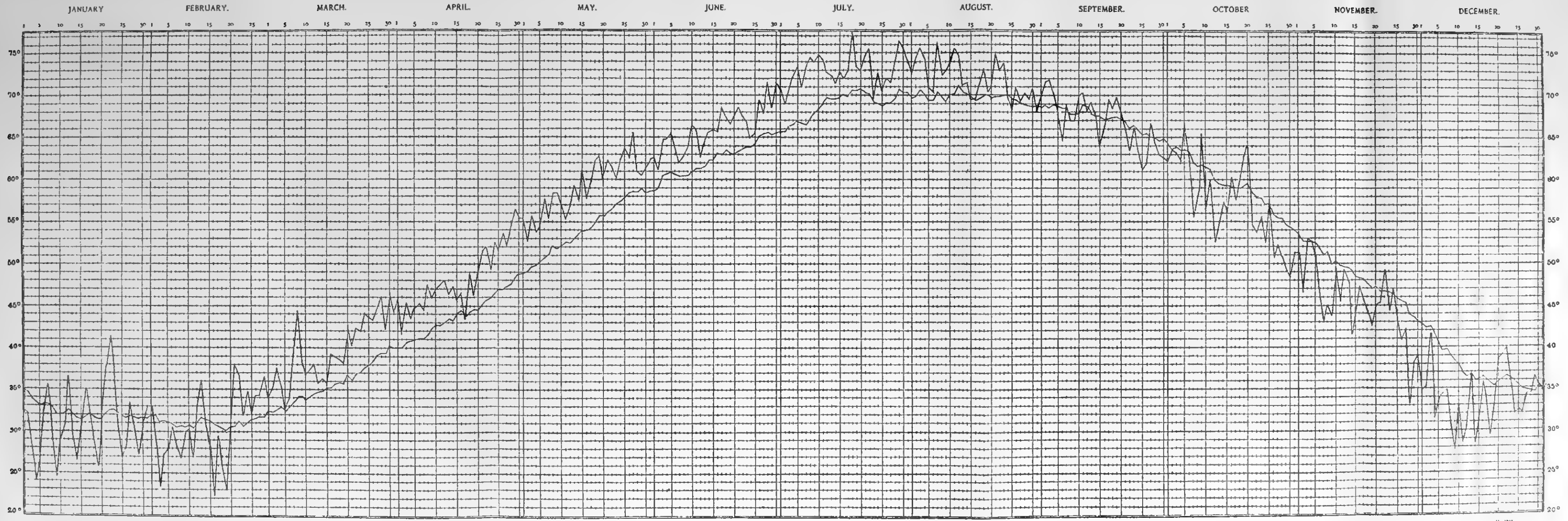


CHART 218.—Density throughout Buzzards Bay and Vineyard Sound, June, 1908.

DIAGRAM SHOWING MEAN AIR AND WATER TEMPERATURE AT WOODS HOLE, MASS., FOR EACH DAY OF THE YEAR, 1902-1906, INCLUSIVE.

The less regular line represents Air Temperature, the more regular one, Water Temperature.



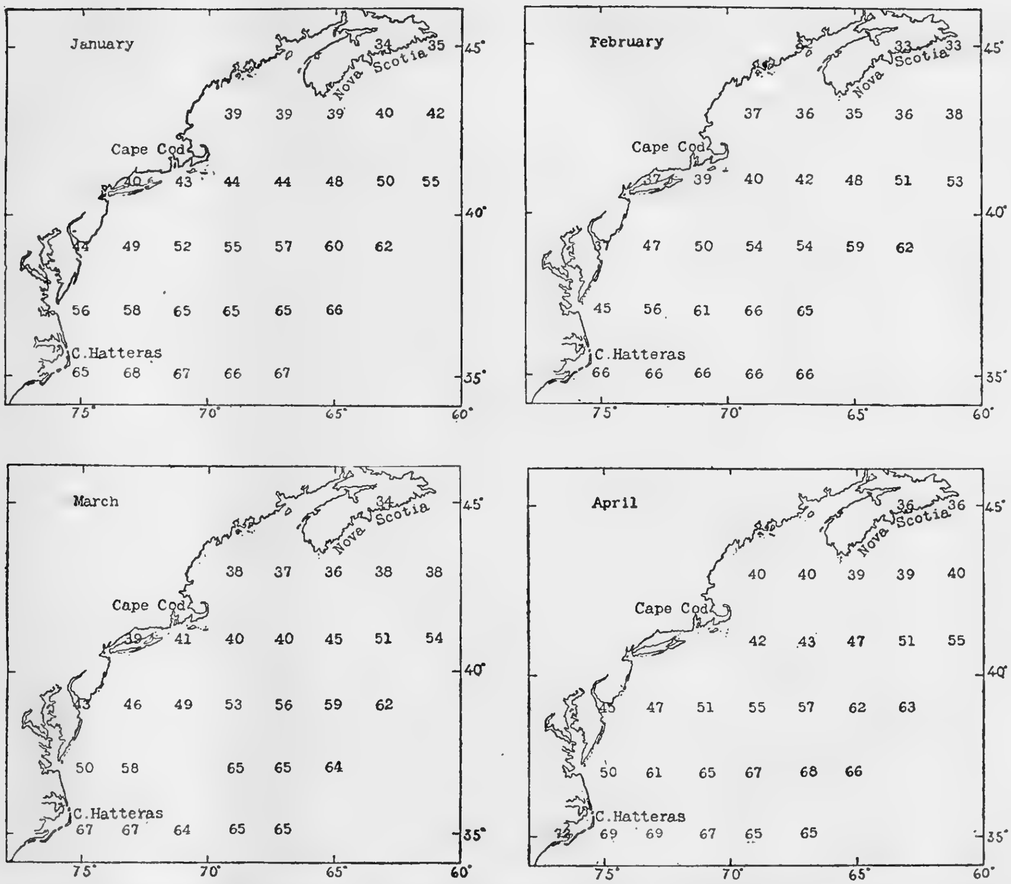


CHART 220.—Surface temperatures, northwestern Atlantic Ocean, during January, February, March, and April. (Furnished by Hydrographic Office, United States Navy Department, from compilation of British Meteorological Office.)

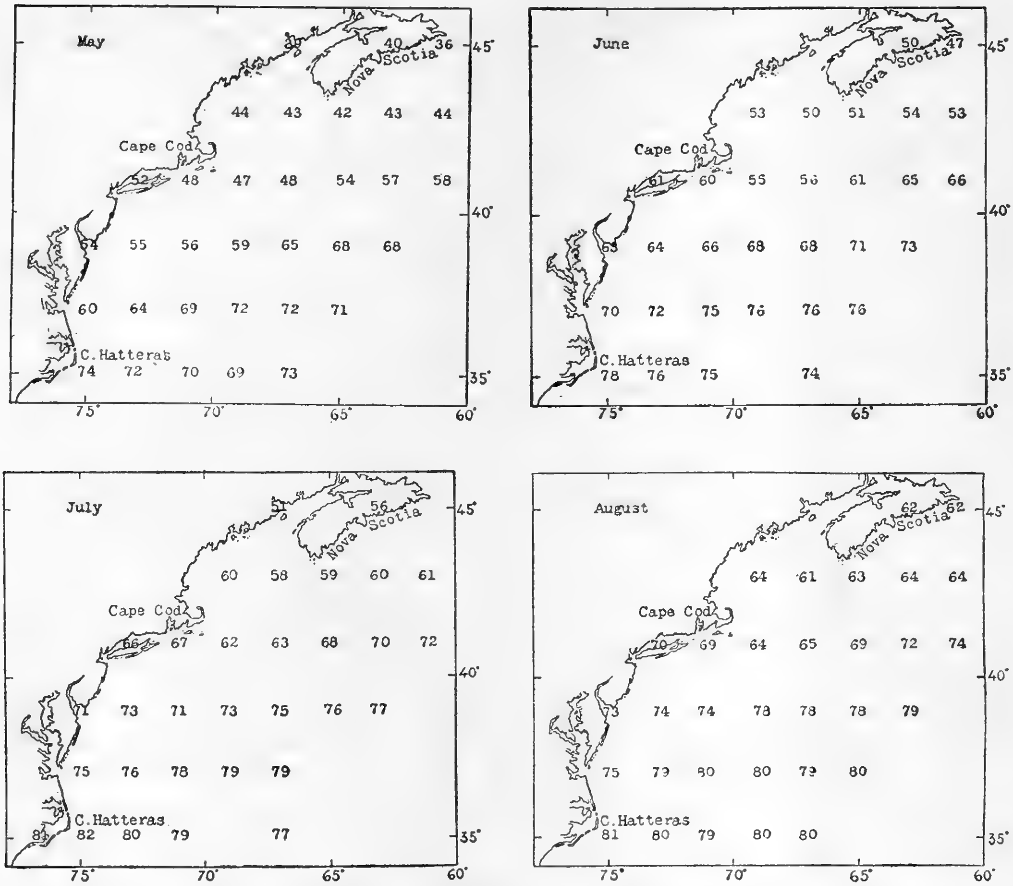


CHART 221.—Surface temperatures, northwestern Atlantic Ocean, during May, June, July, and August. (Furnished by Hydrographic Office, United States Navy Department, from compilation of British Meteorological Office.)

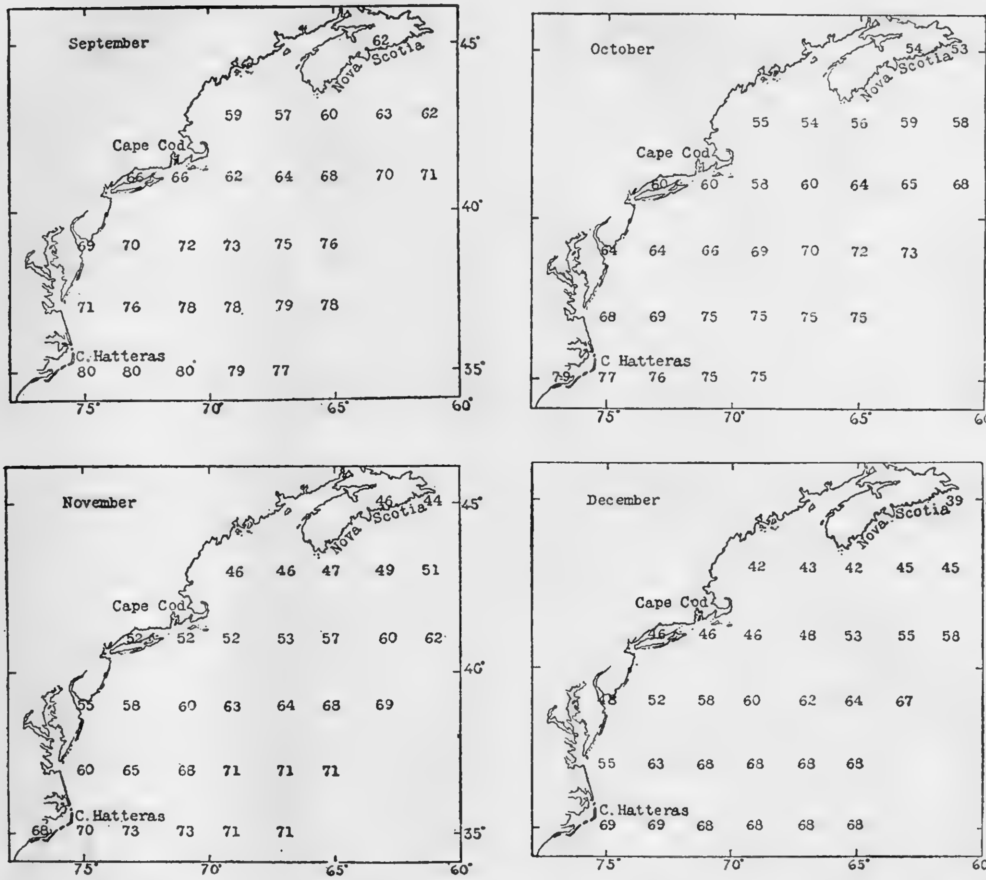


CHART 222.—Surface temperatures, northwestern Atlantic Ocean, during September, October, November, and December. (Furnished by Hydrographic Office, United States Navy Department, from compilation of British Meteorological Office.)

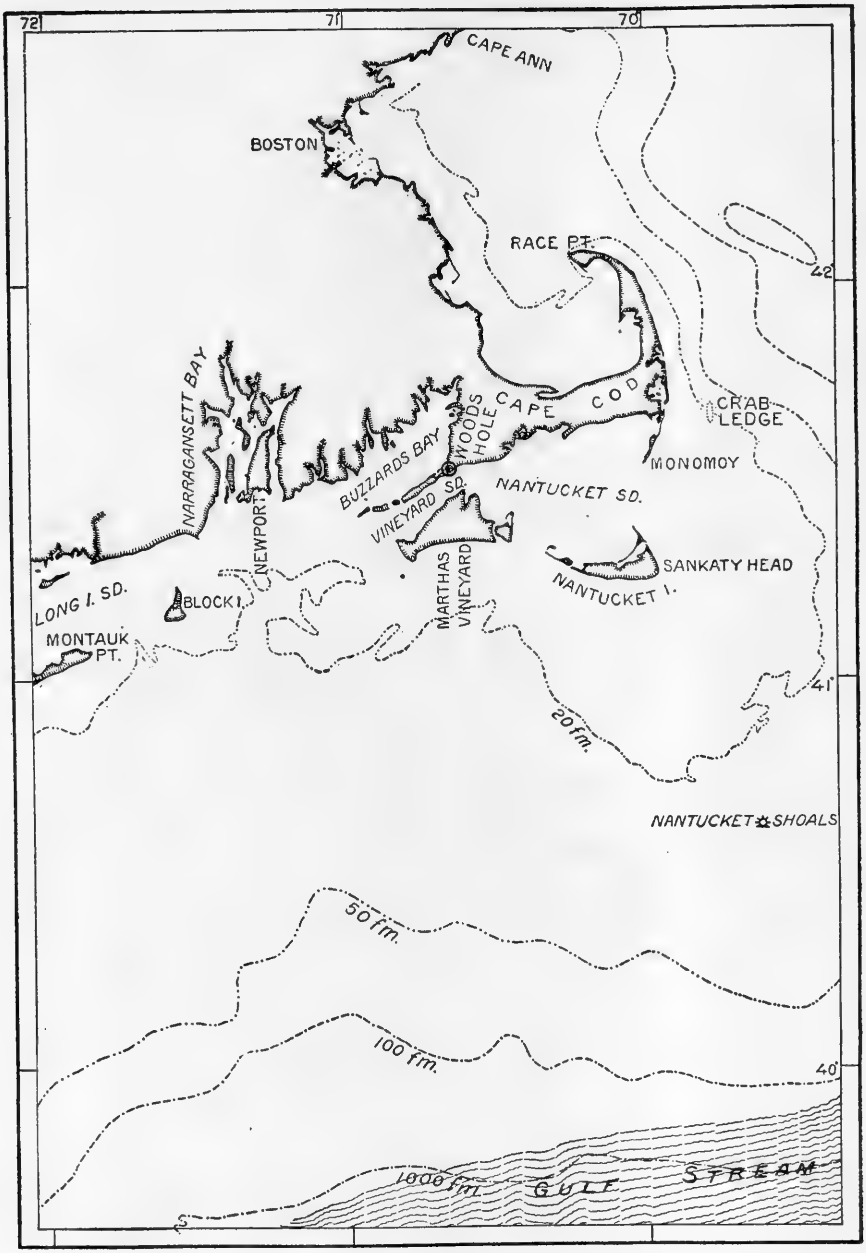


CHART 223.—Cape Cod and neighboring areas of land and water, showing geographic and hydrographic features. (Based in part on U. S. Coast and Geodetic Survey chart no. 1000.)

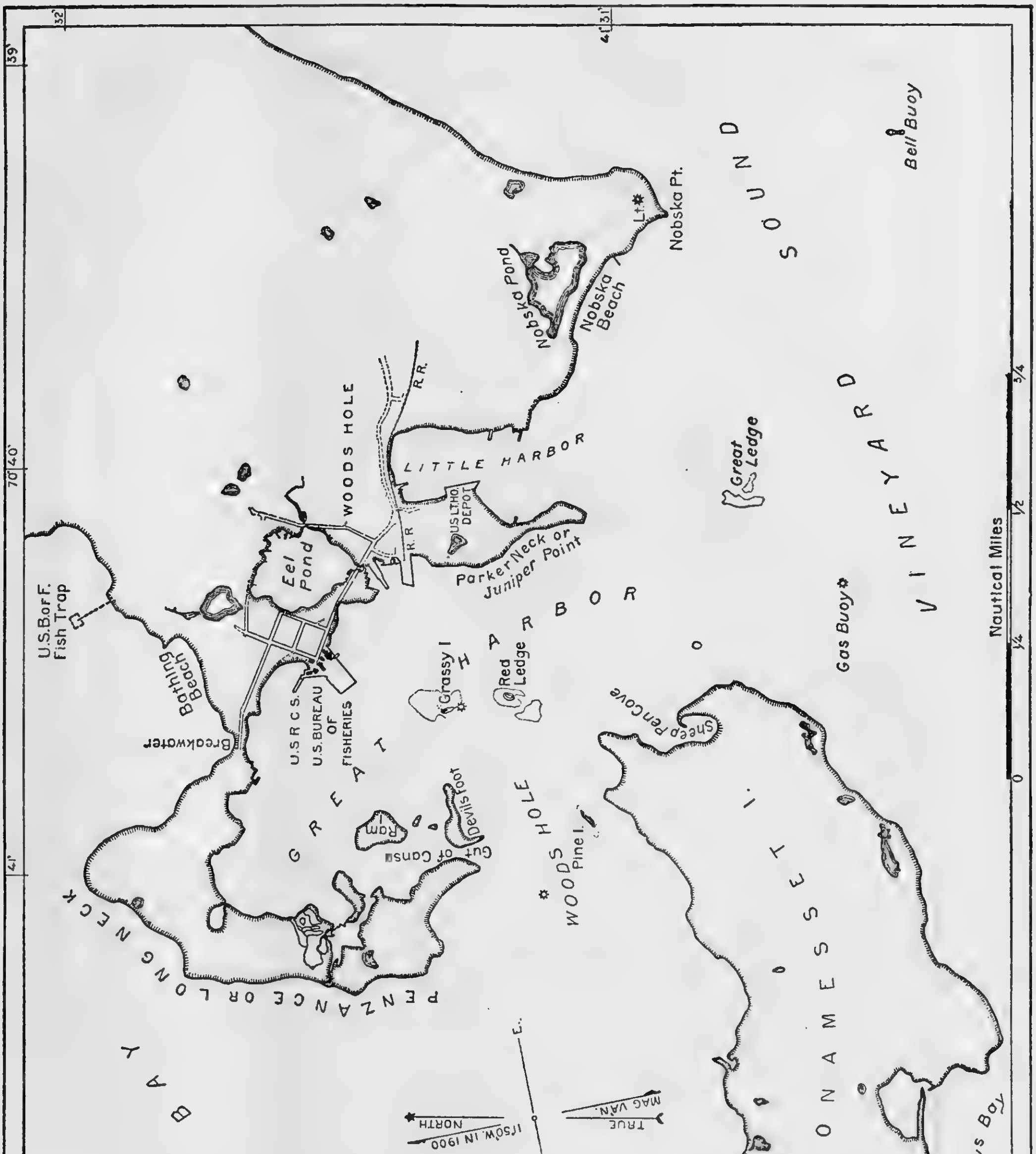
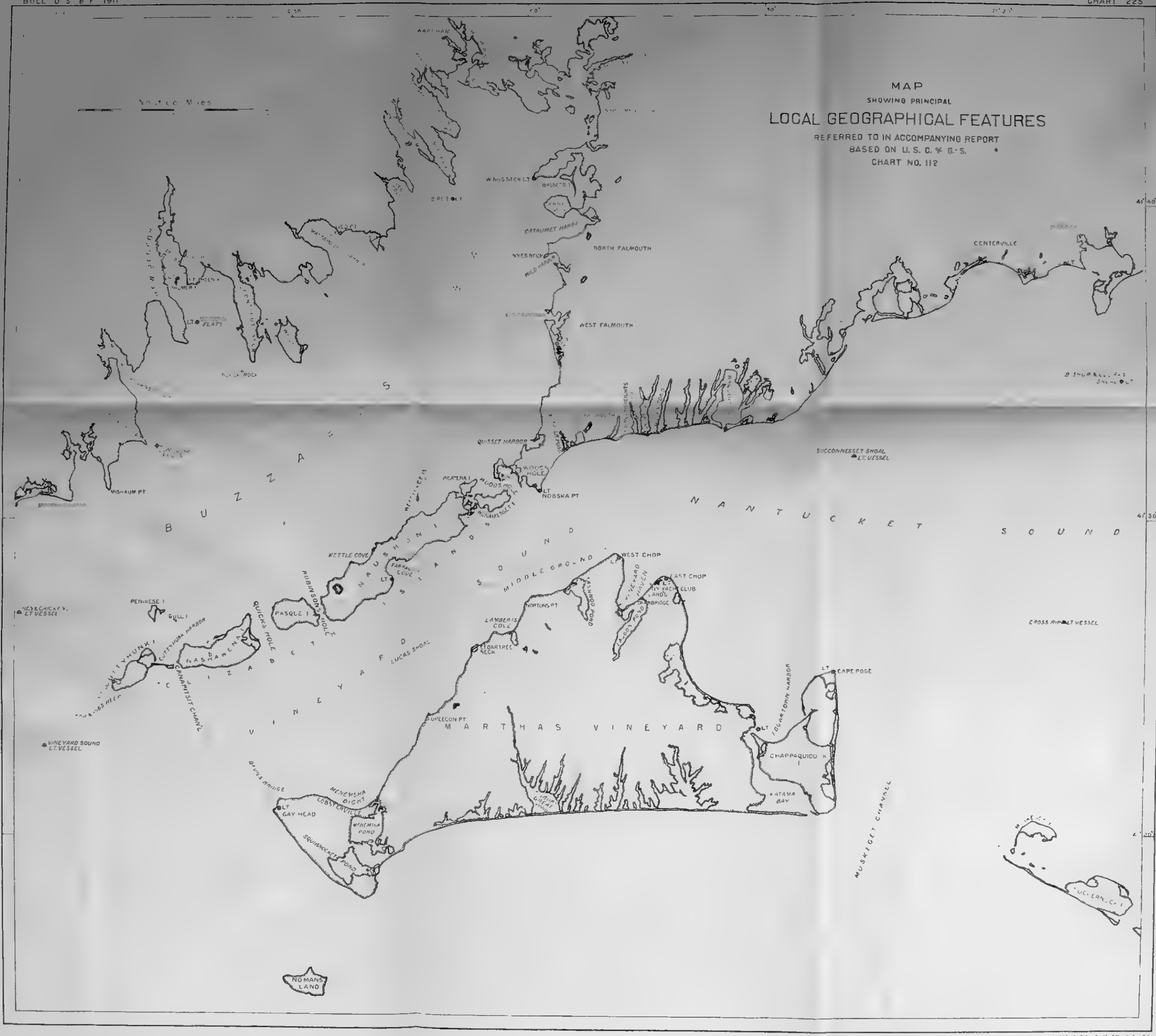


CHART 224.—Woods Hole Harbor and vicinity. (Based on U. S. Coast and Geodetic Survey chart no. 348.)


MAP
SHOWING PRINCIPAL
LOCAL GEOGRAPHICAL FEATURES
REFERRED TO IN ACCOMPANYING REPORT
BASED ON U. S. C. & G. S.
CHART NO. 112
CATAUMET HARBOR
NORTH FALMOUTH
WILD HARBOR
WEST FALMOUTH
CENTERVILLE
QUISSET HARBOR
WOODS HOLE
NOBSKA PT
SUCCONNESSET SHOAL LT. VESSEL
MISHAUM PT
B U Z Z A R D S
N A N T U C K E T S O U N D
KETTLE COVE
NAUSHON I
TARPAULIN COVE
ROBINSONS HOLE
PASQUE I
QUICKS HOLE
PENIKESE I
GULL I
CUTTYHUNK I
CUTTYHUNK HARBOR
NASHAWENA I
CANAPITSIT CHANL
E L I Z A B E T H I S L A N D S
V I N E Y A R D S O U N D
MIDDLE GROUND
LUCAS SHOAL
WEST CHOP
EAST CHOP
VINEYARD HAVEN
LAGOON POND
TASHMOO POND
NORTONS PT
LAMBERTS COVE
CEDARTREE NECK
UPEECON PT
CROSS RIP LT VESSEL
CAPE POGE
EDGARTOWN HARBOR
CHAPPAQUIDDICK I
KATAMA BAY
M A R T H A S V I N E Y A R D
VINEYARD SOUND LT. VESSEL
DEVILS BRIDGE
MENEMSHA BIGHT
LOBSTERVILLE
GAY HEAD
MENEMSHA POND
SQUIBNOCKET POND
GREAT POND
MUSKEGET CHANNEL
NOMANS LAND

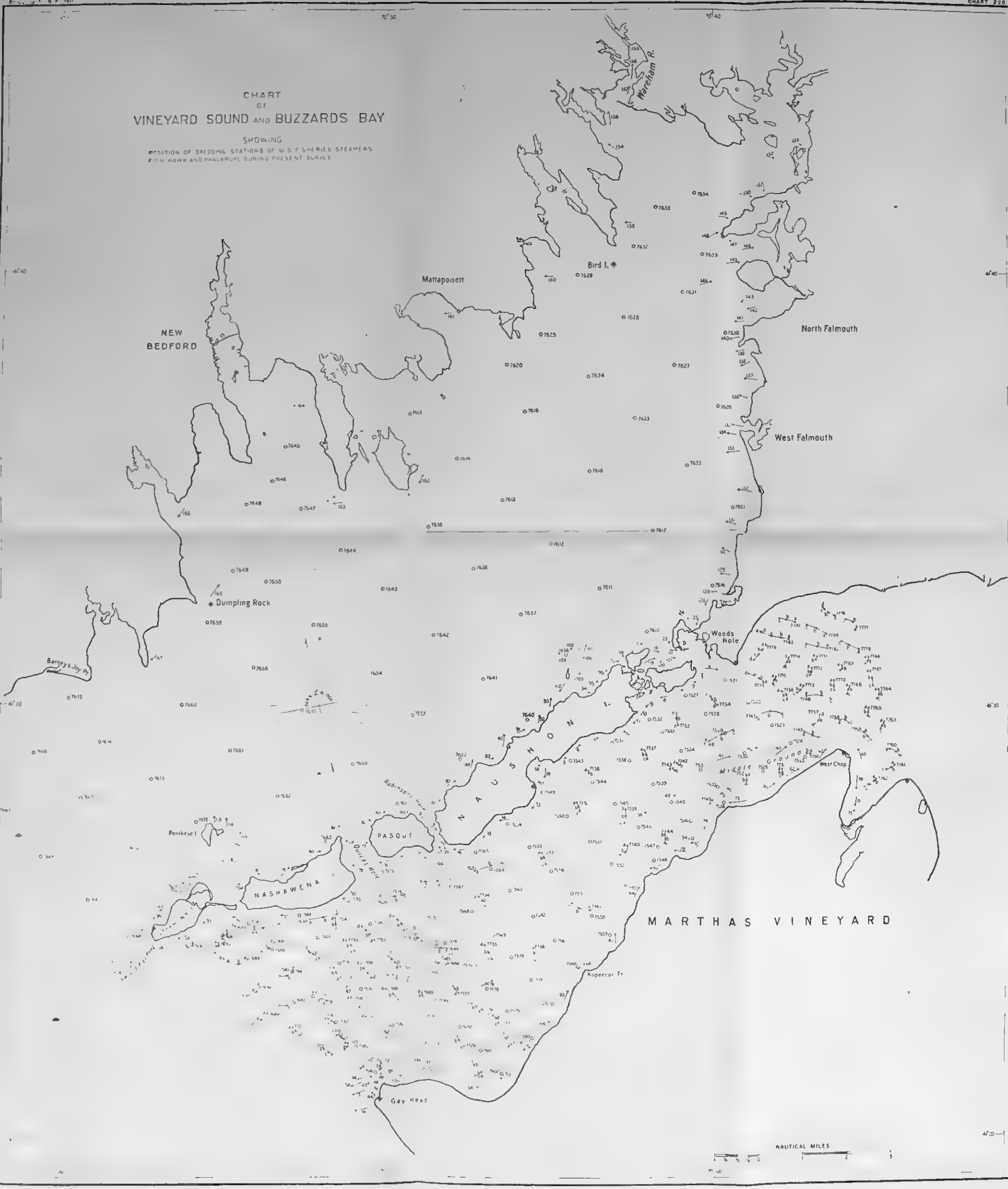


CHART
OF
VINEYARD SOUND AND BUZZARDS BAY
SHOWING
POSITION OF DREDGING STATIONS OF U.S.FISHERIES STEAMERS
FISH HAWK AND PHALAROPE DURING PRESENT SURVEY
70°50
70°40
Wareham R.
Bird I.
Mattapoisett
NEW
BEDFORD
North Falmouth
West Falmouth
Dumpling Rock
Woods
Hole
Barneys Joy Pt.
NAUSHON I.
Robinsons Hole
PASQUE
Quicks Hole
NASHAWENA
Penikese I.
Middle Ground
West Chop
MARTHAS VINEYARD
Gay Head
NAUTICAL MILES

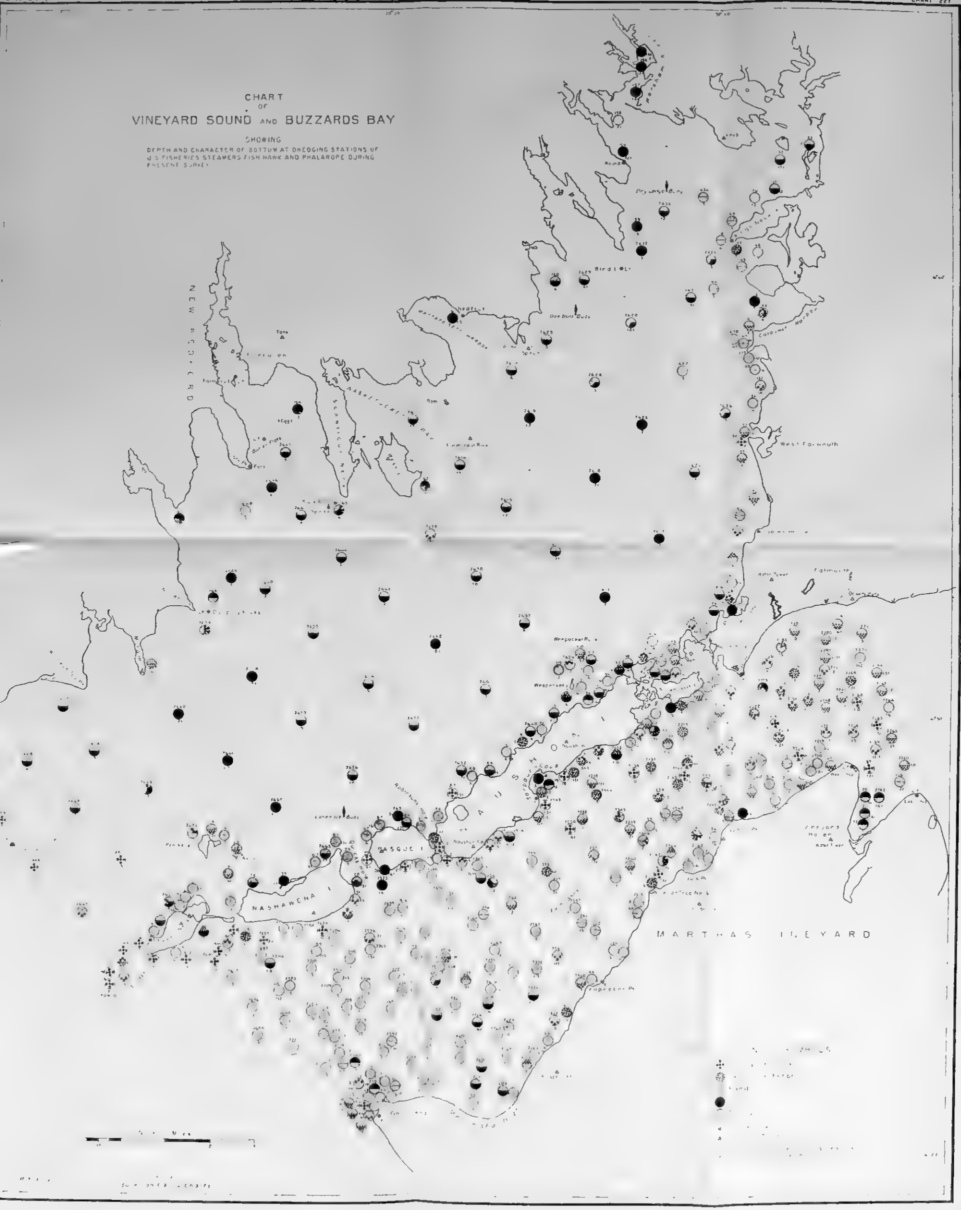


CHART
OF
VINEYARD SOUND AND BUZZARDS BAY
SHOWING
DEPTH AND CHARACTER OF BOTTOM AT DREDGING STATIONS OF U. S. FISHERIES STEAMERS FISH HAWK AND PHALAROPE DURING PRESENT SURVEY
West Falmouth
Falmouth
NASHAWENA I.
PASQUE I.
MARTHAS VINEYARD

Section II.—BOTANICAL.

General Characteristics of the Algal Vegetation of Buzzards Bay and Vineyard Sound in the Vicinity of Woods Hole.

By Bradley Moore Davis.

Chapter I.—INTRODUCTION.

Ever since the publication of Harvey's "Nereis Boreali-Americana," in 1852, 1857, it has been recognized that the marine algæ of the Atlantic coast of North America were separated by Cape Cod into two floras. The distinction was discussed in detail in Farlow's report "The Marine Algæ of New England," 1881, and in his earlier "List of the Sea-weeds or Marine Algæ of the South Coast of New England," 1873. The work of later algologists has only served to emphasize the fundamental differences between the two marine floras, and the results of this survey add further evidence in support of this general conclusion.

Similar conclusions have been reached by zoologists respecting the distribution of marine animals north and south of Cape Cod. The fauna from the cape northward to Labrador is regarded as essentially a continuous one, with no changes that are comparable to those which appear southward. Two faunas separated by Cape Cod have thus been distinguished, and there seems to be a difference between these similar to that between the two marine floras. The most important reasons for the difference between the faunas and floras north and south of Cape Cod are undoubtedly the same.

The marine algæ north of Cape Cod, as pointed out by Farlow (1881), are in general a part and continuation of the flora of Greenland and Newfoundland. Many of the most characteristic species of the flora, as judged quantitatively, are identical with those of the Scandinavian coast, and it seems clear that the algæ of the west and east side of the north Atlantic are a part of a general Atlantic boreal flora.

The reason for the boreal character of the algal flora north of Cape Cod is undoubtedly the low range of temperature which prevails even through the warmer months of the year. The coast is bathed by a belt of cold water that lies between the coast and the Gulf Stream, this belt being from 200 to 250 miles broad off a large part of the New England coast, although the Gulf Stream is only about 80 miles from Marthas Vineyard and Nantucket. The temperature of these waters, except in sheltered situations, only reaches 60° F. or slightly above for a few weeks in midsummer, and for the greater part of the year is below 50°, and remains below 40° throughout the winter. The explanation of this condition involves a number of factors, which are discussed in section 1, chapter II, pages 35 and 51, to which the reader is referred for details. The most important point for present consideration is the undisputed fact of the presence of a belt of relatively cold water north of Cape Cod, lying between the Gulf Stream and the New England shores, which directly influences the algal flora.

The marine algæ south of Cape Cod may be grouped into what Harvey (1852, p. 26) calls the flora of Long Island Sound, extending from Cape Cod to New Jersey. It includes

a large number of species not found at all north of Cape Cod and some that have been reported only in a few sheltered situations where the temperature of the summer undoubtedly rises much above the average of the general region. It comprises certain species which are present in the north Adriatic and other parts of the Mediterranean and some that are found south of New Jersey, in the West Indies, and in other warmer seas. The generally sandy character of the coast from New Jersey southward serves to separate the flora of Long Island Sound from that of Key West and the West Indies. Certain species that are typically northern or arctic in their habitats are found all the year round in some localities south of Cape Cod where the conditions are sufficiently favorable for their growth, and a number of other species appear in the winter season. However, the algal flora of the summer stands in sharp contrast to that north of Cape Cod, and resembles in many respects the floras of warmer seas, although a number of important groups, characteristic of such regions, are not represented in the flora of Long Island Sound.

The reasons for the peculiarities which are noticed at once in the algal flora south of Cape Cod are in general quite as evident as are those for the boreal characteristics north of the cape. Cape Cod forms a barrier which holds the cold waters of the north somewhat as in a pocket and greatly checks their mingling directly with the waters of Nantucket and Vineyard Sounds to the south. Nantucket and Marthas Vineyard, together with various shoals, form barriers which still further protect these sheltered sounds from the cooler water which lies off such exposed points as Gay Head and No Mans Land. This offshore cooler water is probably an extension of the cold belt north of Cape Cod, which continues southward around the cape. The proximity of the Gulf Stream, which lies only about 80 nautical miles off the coast of Nantucket, is also a factor of considerable importance. While the Gulf Stream does not send any well-marked side currents toward the coast, it must, nevertheless, greatly modify the temperature of the water which lies between it and the shore. It is well known that southerly storms bring surface water from the Gulf Stream toward the coast, for masses of gulf-weed, *Sargassum bacciferum,* with animal inhabitants characteristic of sargasso seas (such as the nudibranch, *Scyllæa pelagica*, certain crabs, *Planes minutus* and *Portunus sayi*, and the fish *Pterophryne historio*) are not infrequently found in Vineyard Sound and other bodies of water, especially where tidal currents are so strong as to bring them near to land.

The waters south of Cape Cod, embracing such bodies as Vineyard Sound, Buzzards Bay, Narragansett Bay, Long Island Sound, and the regions that lie between, are then effectively protected from the influence of the cold water north and east of the cape, and consequently are able to become relatively warm during the summer months. The fact that these waters are generally shallow permits them to respond very quickly to the atmospheric changes at different seasons and makes possible great extremes during the year. Their temperature in the winter falls close to freezing point, but rises in the summer to 70° F. and above. Some of the most sheltered harbors and bays may even become much warmer than that during the summer, while they regularly freeze over in the winter. Such a wide range of temperature throughout the year permits a great variety in the life conditions, which is expressed by sharp seasonal changes in the character of the flora. It is the high temperature of the summer which at this season accounts for the development of the characteristic summer algal flora with its resemblance to the floras of southern seas.

Chapter II.—SOME FACTORS AFFECTING THE DISTRIBUTION OF ALGÆ AT WOODS HOLE AND VICINITY.

1. THE COAST.

The shore line of Woods Hole, of the Elizabeth Islands, and of neighboring regions along Vineyard Sound and Buzzards Bay is in some respects remarkably varied (see chart 225), but lacks certain important physical features present in other localities. The coast, wherever exposed to wave action or tide currents, is composed of bowlders and stones or consists of sandy and stony beaches. This is because the bowlders and stones have remained at the shore line as the finer material of the glacial deposits covering this region was washed away by the erosion of the coast. The sheltered coves, bays, and harbors will generally have a sandy or muddy shore, sometimes gravelly, with scattered groups of stones or bowlders. There are also small salt marshes connected with some of the coves, as at Quisset and Hadley Harbor. There are no outcroppings of rock, except in the vicinity of New Bedford Harbor, to make possible perpendicular or slanting ledges and rock pools. An account of the geography of the region, together with the character of the shores, is given in section I, chapter II, pages 28 and 29.

For the reasons stated above one misses some of the very characteristic associations of algæ which may be noted in tide pools and along the sides of rock masses where there is opportunity for the development of conspicuous bands or zones of vegetation between tide marks and below—associations that are well illustrated in such localities as Newport and at Nahant, near Boston. A shore of bowlders presents a broken line at the water's edge which can not show to full advantage the distribution of algæ in zones. There are good illustrations of zonation in places, but they are on a comparatively small scale and become evident only as groups of rocks or parts of the shore are studied in detail, as was done for Spindle Rocks in the harbor of Woods Hole, to be described later (pages 476–479). Another factor that works against the conspicuous zonation of algæ in this region is the relatively small tide, which does not give much opportunity for the development of broad zones of differentiated algal growth.

2. THE BOTTOM IN DEEPER WATER.

As would be expected in an area of glacial drift, the bottom offshore and in the deeper portions of Buzzards Bay and Vineyard Sound may consist of sand, gravel, or stones, with or without deposits of mud, but is frequently of a more or less mixed or spotted character. Channels swept by swift tides are likely to be stony and sandy, while sheltered coves, bays, or other regions, free from the scouring action of tidal currents, usually have a muddy bottom. The ledges or other areas composed of bowlders are simply piles of stones heaped together where they were laid after the finer matrix of the glacial drift had been washed away. The muddy bottoms are due to deposits of silt where the water is sufficiently quiet because of its depth, or because of the absence of tidal currents or wave action sufficiently strong to prevent the accumu-

lation and settling of finer material. A detailed description of the bottom characters will be found in section I, chapter II, pages 29–33, and the peculiarities are graphically presented on chart 227.

The luxuriance and to a large extent the nature of the algal vegetation depends upon the character of the bottom. Rocky, stony, and shelly bottoms are the most favorable for the attachment of algæ and, in general, support the heaviest growths of marine vegetation. Sandy and muddy bottoms are less favorable and are generally very barren, although some species are confined to such situations. It is clear that the shifting nature of sand and mud, frequently stirred by tides and storms, presents conditions very unfavorable for the germination of algal spores, which quickly become covered by sediment. Sandy or muddy bottoms are, however, apparently necessary for the development of extensive beds of the eel grass, *Zostera marina*.

3. THE TIDES AND TIDAL CURRENTS.

As stated before, the tides at Woods Hole and adjacent portions of Buzzards Bay and Vineyard Sound are of relatively slight amplitude. There is considerable variation at different points in the Bay and Sound and in the harbor of Woods Hole, due to the peculiarities of the tidal currents in the region. At Woods Hole, on the Sound side, and in Vineyard Haven the average tide is 1.7 feet, at Gay Head it is 3 feet, in Buzzards Bay at Woods Hole 4.1 feet. With such small tides it is clear that the strip along the shore habitable for a littoral algal flora—that is, a flora above the lowest tide mark—could not be very broad. It is generally only a few feet wide, and one notices at once in this region that the receding tide fails to expose broad stretches of rock, sand, or mud in the manner characteristic of the coast north of Cape Cod, where the tides are much greater.

The arrangement of the land that bounds Vineyard and Nantucket Sounds is responsible for the remarkable tidal currents that flow east and west in Vineyard Sound, and in and out of Buzzards Bay through the channels of Woods Hole, Robinsons Hole, and Quicks Hole. These tidal currents must be very effective in distributing algal spores, and it seems probable that the rapidity with which algal vegetation springs up after each change of season (as over areas scraped clear by floating ice) must be due, at least in large measure, to the tidal currents. It is certain that any alga which develops large crops of spores has by such means the opportunity of distributing these very rapidly throughout practically all of the waters of this region. This factor must be of considerable importance in securing the almost universal presence of some species that can grow under a wide range of life conditions, as well as the appearance of others at distantly separated stations.

4. THE EFFECT OF ICE.

The upper portions of Buzzards Bay are at times during the winter more or less completely frozen over, and small harbors, such as Little Harbor at Woods Hole, may have a thick covering of ice. Sheltered portions of the coast, which are not exposed to surf or stong tidal currents, are fringed with ice. There is also much floating ice in the Bay and Sound consisting of large cakes which come from the breaking up of larger masses. This floating ice is swept by the tides back and forth in the Bay and Sound and through such channels as Woods Hole.

The movement of the ice along the shore and through the channels, whether due to the rise and fall of the tide, to storms, or to tidal currents, serves to scrape bare the large stones and bowlders, wherever they are exposed, so that they are frequently almost or entirely free from algæ in the spring when the ice disappears. These effects are particularly evident on the exposed shore line of the upper portion of Buzzards Bay and in portions of Vineyard Sound, where the rocks in the winter are not only bare of algæ, but also at times free from the common barnacle (*Balanus balanoides*) which covers their surfaces in the summer. This action of the ice along exposed shores and channels thus prevents or greatly reduces the littoral growth during the winter, when the conditions are most favorable for the development of a very characteristic flora, with species of the rockweeds (Fucaceæ) as the most conspicuous forms. If it were not for these facts we should expect in the winter heavy fringes of rockweeds along the shore, for these grow luxuriantly where they are not exposed to the scraping of the ice, as, for example, along the shore of Cuttyhunk and elsewhere in the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound.

The scraping effects of ice on a particular group of rocks may be better understood by comparing chart 267 of Spindle Rocks with chart 274 and the charts that show the coming in of the spring and summer floras after the ice has disappeared (charts 268, 269, and 270). Rocks which are perfectly bare after the winter become thickly covered during the spring and summer with algæ characteristic of these seasons.

5. DEPTH OF WATER.

Buzzards Bay and Vineyard Sound are relatively shallow bodies of water. As may be seen from chart 227, at only a few stations was a depth greater than 18 fathoms obtained. There were a number of stations with a depth between 14 and 17½ fathoms, but by far the larger number in the middle regions of both Bay and Sound were between 8 and 14 fathoms. The Bay in general gradually deepens toward the lower portion, but the Sound, on the contrary, shows no marked progressive deepening toward the western end.

The depth at which algæ will grow is determined chiefly by the penetrating power of light and consequently varies in different seas according to the relative amount of sunshine during the year and the clearness of the water. Rosenvinge (1898, p. 233) places 20 fathoms as about the limit of growth for algæ in northern seas where, however, the proportion of cloudy and foggy days is very large. Börgesen (1905, p. 700) found the limit of growth around the Faroes to be between 25 and 30 fathoms. In southern seas, where there is a very large proportion of sunny days and more direct penetration of the sun's rays, as in the Bay of Naples and off the Balearic Islands (Rodríguez 1888) in the Mediterranean, deep-water algæ have been reported to grow at 50 to 100 fathoms. Most of the species at these great depths belong to the Rhodophyceæ, but there are many of the Phæophyceæ in water deeper than 50 fathoms, and several species of the Chlorophyceæ are found at 20 to 60 fathoms.

With respect to the amount of sunlight during the year Woods Hole probably stands somewhat midway between the conditions over northern seas and those of the south. It certainly has both in winter and summer a large proportion of fair and sunny days. Consequently there are no parts of either Buzzards Bay or Vineyard Sound included in the limits of the survey that are too deep for certain algæ. The dredgings of the Survey

at the deepest stations have shown abundant growths of algæ wherever the bottom was suitable, but two of the deepest stations in the westerly portion of Vineyard Sound (7682 and 7683, 19 and 19½ fathoms, respectively) were over a sandy bottom unfavorable for the attachment of algæ. Station 7670 (19 fathoms), in Buzzards Bay west of the island of Penikese, showed a stony bottom with many plants of *Laminaria Agardhii* var. *vittata*, and in small quantity *Champia parvula*, *Chondrus crispus*, *Ceramium rubrum*, *Grinnellia americana*, *Polysiphonia urceolata*, and *Rhodymenia palmata*.

6. LIGHT.

As stated above, the depth to which certain algæ may descend depends upon the penetration of light. The factor that determines the lowest limits of algal life is not depth of water but absence of light.

The Cyanophyceæ, or blue green algæ, and the Chlorophyceæ, or green algæ, require the greatest illumination and are rarely, if ever, found at Woods Hole and vicinity in water more than 2 or 3 fathoms deep, but are for the most part near the surface or between tide marks. The Rhodophyceæ, or red algæ, reach the lowest depths, although many species grow near low-water mark and some even above it. The Phæophyceæ, or brown algæ, are somewhat midway between the green and the red algæ in their light relations. Some species of the brown algæ grow at low-water mark and above, but many grow below low water and to a considerable depth; few, however, are found at the greater depths of the red algæ. There are apparently no regions in Buzzards Bay and Vineyard Sound too deep for certain species of brown algæ, for *Desmarestia aculeata*, *Laminaria Agardhii*, and *Laminaria Agardhii* var. *vittata* were found between 17 and 19 fathoms. The list of red algæ present at these depths (17 to 19 fathoms) is, however, much longer: *Champia parvula*, *Chondrus crispus*, *Cystoclonium purpurascens* var. *cirrhosum*, *Delesseria sinuosa*, *Grinnellia americana*, *Phyllophora Brodiæi*, *Phyllophora membranifolia*, *Plumaria elegans*, *Polysiphonia elongata*, *Polysiphonia urceolata*, *Rhodymenia palmata*, *Spermothamnion Turneri*.

There is therefore in a broad sense a distribution of algæ in zones depending upon light relations, the blue-green and green algæ growing under the brightest illumination, the brown algæ requiring on the whole less light, and the red algæ able to flourish under the weakest illumination. It must constantly be borne in mind, however, that there is always an overlapping in the habitat of species among these groups, many brown and red algæ growing side by side and even with the green algæ under very bright illumination.

It is a matter of dispute whether the life habits of marine algæ with respect to illumination are influenced chiefly by the quality of the light or by the quantity. The red rays of sunlight, it is claimed, can not penetrate much below 7 fathoms, and the light at greater depths is mainly composed of blue and green rays, is feeble in yellow, and lacks red rays entirely. Certain investigators, notably Engelmann (1883, 1884) and Gaidukov (1902, 1904, 1906), hold that the quality of the light rather than its intensity determines the distribution of the green, brown, and red algæ. According to this view the green algæ grow under bright illumination because they require the maximum of red rays, while the red algæ are able to live in deep water because their color allows them to absorb the green rays which they especially need. The brown algæ in general adjust themselves to light conditions intermediate between these extremes. It is well known that a number of the Rhodophyceæ which grow near the surface of the

water are colored, not the characteristic red of this group, but shades of brown and green; for example, the Irish moss, *Chondrus crispus*, is frequently green under bright illumination in the summer at Woods Hole. Furthermore, Nadson (1900) has shown that certain species of the Cyanophyceæ and Chlorophyceæ, which are green near the surface, take on reddish colors in deep water.

These conclusions that the colors of algæ depend upon the quality of the light are opposed to views held by Berthold (1882), Oltmanns (1892), and others who have considered the Rhodophyceæ to be merely shade plants, the distribution of which was determined by the quantity of light. They have made much of the fact that in dimly lighted caves and shaded situations red algæ, which usually grow at some depth, are found very near the surface; but it should be borne in mind, as Börgesen (1905, pp. 702, 703) points out, that while these algæ receive a much weaker white light in these caves, they may have the benefit of much blue and green reflected light.

Gaidukov (1902, 1906), in a series of interesting experiments, has shown that certain algæ (species of *Oscillatoria*, *Phormidium*, and *Porphyra*) take on complementary colors when subjected to pure rays from a spectrum, becoming, for example, green under red and yellow light and red or purplish under green or blue light. This phenomenon, called complementary chromatic adaptation, is shown only by living plants and is believed to involve changes in the structure of the pigments. The reason why green algæ can not live in deep water is clear, since the red rays upon which they depend are not there present. The red algæ, on the contrary, may live at the surface as well as at depths below the penetration of red rays, but at the surface they meet the competition with green algæ from which they are free in deep water.

However, it can not be said that all of the phenomena are clearly explained by the hypothesis of chromatic adaptation held by Engelmann and Gaidukov. Thus, Rodríguez (1888) reports the following Chlorophyceæ off the Balearic Islands at much greater depths than would be expected for any of the green algæ: *Palmophyllum orbicularis* Thuret, 130 meters; *Cladophora pellucida* Kützing, 40 meters; *Codium tomentosum* Agardh, 48 meters; *C. tomentosum* var. *elongatum*, 90 to 100 meters; *Udotea Desfontainii* Decaisne, 120 meters; and somewhat similar records are known for certain of the Chlorophyceæ in the Gulf of Naples.

7. TEMPERATURE AND SEASONAL CHANGES.

The temperature of the water, the depth, and the character of the bottom are the chief factors in determining the distribution of the algæ in the region covered by the survey. The influence of temperature must be of fundamental importance where the seasonal extremes are as great as those of the summer and winter at Woods Hole. The conditions in the winter would admit a rich northern or boreal algal flora at Woods Hole were it possible for the species to reach this sheltered situation by traveling around Cape Cod and to survive the warm summer. As it is, a number of northern species do grow at Woods Hole in the favorable winter and spring seasons and some are able to vegetate through the summer. In striking contrast with the winter's cold is the summer temperature, which is so high that it can support a flora with many points of resemblance to the floras of warmer seas. The subject of temperature receives considerable attention in section 1, chapter II, pages 38–52, where the detailed records of the Survey

are presented in a series of tables, and likewise on charts 211 to 214, giving the location of the stations.

The average monthly temperature of the water off the Government wharf in Great Harbor, Woods Hole, for the years 1902–1906 (five years) is given in table 10, page 47, and the seasonal changes are portrayed graphically in chart 219. It will be seen that during January, February, and March the mean temperature was below 35° F. The period when the temperature was below 35° actually extended from about December 25 to March 15, and this may be considered the winter season. After March 15 the temperature rose rapidly, passing 60° about June 1; this constitutes a spring season. Between June 1 and October 12 the temperature remained above 60°, holding between 69° and 71° from July 11 to August 28, a period of 48 days; this is the long summer season of warm water. After October 12 the temperature fell rapidly from 60°, until December 11, when it reached 37°, and it remained between 37° and 35° until December 26, when it passed below 35°; this period may be considered the autumn season. A table of averages such as that of table 10 does not give the extremes of temperature, the lowest of which was 28½° in January and February, and the highest 74° in July and 74.5° in August. It should also be remembered that the extremes are much greater in situations more sheltered than Great Harbor, Woods Hole, as, for example, in the upper portions of Buzzards Bay, where the water may be heavily frozen for several weeks and the summer temperature probably rises close to 80°.

It is very important to contrast the seasonal range of temperature at Woods Hole with that of the bottom water between Gay Head and the ledges of Sow and Pigs, for in this region of the survey the range of temperature is the least. On August 16, 1907, the bottom temperature off Gay Head was 57.2° F. (16¾ fathoms) and 59.2° (11¾ fathoms), off Sow and Pigs 60.1° (10½ fathoms), and in Vineyard Sound between these two points 55° (17¾ fathoms); the surface temperature at these stations was from 3° to 5° higher. On November 12, 1907, the bottom temperature off Gay Head was 51.9° (10½ fathoms), off Sow and Pigs also 51.9° (8 fathoms), and in Vineyard Sound between these points 52° (18 fathoms); the surface temperature at these points was about 1° lower. On March 20, 1908, the bottom temperature off Gay Head was 36.6° (8 fathoms), off Sow and Pigs 36.6° (5 fathoms), and in Vineyard Sound between these two points 37.4° (18 fathoms); the surface temperatures being almost the same. On June 6, 1908, the bottom temperature off Gay Head was 57.6° (12½ fathoms), off Sow and Pigs 55.1° (7½ fathoms), and on June 5 in Vineyard Sound between these two points 53.3° (18 fathoms); the surface temperature at these points was then from 1° to 3° higher. These data are presented in tabular form below, the surface temperature being given above the line and the bottom temperature below.

	Aug. 16, 1907.	Nov. 12, 1907.	Mar. 20, 1908.	June 5–6, 1908.
Off Gay Head	$\frac{63.8^\circ}{57.2^\circ}$ (16 fath.) $\frac{62.4^\circ}{59.2^\circ}$ (11¾ fath.)	$\frac{50.7^\circ}{51.9^\circ}$ (10½ fath.)	$\frac{36.8^\circ}{36.6^\circ}$ (8 fath.)	$\frac{59.3^\circ}{57.6^\circ}$ (12½ fath.) (June 6)
Off Sow and Pigs	$\frac{63.1^\circ}{60.1^\circ}$ (10½ fath.)	$\frac{51.2^\circ}{51.9^\circ}$ (8 fath.)	$\frac{36.5^\circ}{36.6^\circ}$ (5 fath.)	$\frac{56.1^\circ}{55.1^\circ}$ (7½ fath.) (June 6)
Between Gay Head and Sow and Pigs	$\frac{60.3^\circ}{55^\circ}$ (17¾ fath.)	$\frac{51.2^\circ}{52^\circ}$ (18 fath.)	$\frac{36.7^\circ}{37.4^\circ}$ (18 fath.)	$\frac{57^\circ}{53.3^\circ}$ (18 fath.) (June 5)

These records of the bottom temperature between Gay Head and the ledges of Sow and Pigs indicate that the average range is from below 35° in the winter to about 60° in the summer. The bottom temperature probably does not fall to the lowest winter temperature of the sheltered waters of the Bay and Sound and does not rise to within 15° of the highest summer temperatures in such situations; the total range is close to 26°. The surface temperature between Gay Head and the ledges of Sow and Pigs is at times in the summer 4° to 5° higher than the bottom temperature, and in the winter probably somewhat lower; the total range is close to 32°. The seasonal range in Great Harbor, Woods Hole, is about 46°, and it must be more than 50° in the upper portions of Buzzards Bay.

The causes of these very different conditions are not difficult to understand. The great range of temperature in the sheltered waters of the Bay and Sound is simply the result of summer and winter atmospheric temperatures acting on bodies of water sufficiently shallow to respond very quickly to their influences. Tables 9 and 10 (pp. 46–47), giving the average monthly range of the temperatures of both air and water at Woods Hole over a five-year period, make clear the relationship, also shown on chart 219. The small range of the temperature of the bottom water between Gay Head and the Sow and Pigs, together with the greater range of the surface water, shows the effect of proximity to the deeper cold water of the open sea, water which, as stated before, appears to be an extension of the cold belt north of Cape Cod.

It is clear from the above statements of the seasonal ranges of temperature in the two extremes of the conditions presented within the limits of the Survey (first, the bottom temperatures off Gay Head and Sow and Pigs; second, the temperatures of sheltered waters of the Bay and Sound) that several very different types of floras would be expected, and this is the case. The uniformly cool bottom water of Gay Head and the Sow and Pigs (generally below 60°) admits of the development of a flora with a number of species characteristic of northern waters. This flora is restricted to the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound and is distinguished by the presence of the following species which are never found (at least during the summer) in the more sheltered regions of the Bay and Sound: *Chætomorpha melagonium*, *Laminaria digitata*, *Plumaria elegans*, *Rhodomela subfusca*, *Actinococcus peltæformis*, *Gymnogongrus norvegicus*, *Euthora cristata*, *Lomentaria rosea*, *Rhodymenia palmata*, *Delesseria sinuosa*. It would be very interesting to know whether other northerly species may not be present during the winter and spring and whether this cold-water flora extends its range during the winter into more sheltered portions of the Bay and Sound, but we have made no dredgings for algæ off Gay Head in the winter and know nothing of the deep-water flora of that season.

The seasonal extremes in the sheltered portions of Buzzards Bay and Vineyard Sound, as would be expected, give at least two distinct seasonal floras, (1) that of the winter and early spring, and (2) that of midsummer and the early autumn. Some species are found all the year round, but they are generally much more luxuriant at one season than at the other. Many of the species are limited to a season of perhaps two or three months and are never found at other times. It is not at present possible to discuss satisfactorily the seasonal habits of the algæ at Woods Hole, for they have been very little studied during the winter, but such data as are known are included in the Catalogue.

The study of Spindle Rocks (pages 476–479) has shown in a rather surprising way the degree of change which takes place on a small mass of rocks over a 12-month period.

The northerly species which would be most likely to invade the Bay and Sound during the favorable winter season would be forms that reproduce rapidly through large crops of spores and mature so quickly that several generations may develop during the season. The tidal currents of the region would serve to distribute such species very widely, even though the favorable season might be short.

8. SALINITY OF THE WATER.

There are no fresh-water streams of importance in the immediate vicinity of Woods Hole to affect markedly the salinity of its waters, which are not much less dense than the open sea, having an average density of about 1.024 (the density of water in the north Atlantic being from 1.027 to 1.028). In the westerly portion of Vineyard Sound and lower portion of Buzzards Bay the density is somewhat greater, having been found at one point as high as 1.0243 (November, 1907). In the extreme upper portion of Buzzards Bay the density is considerably less than at Woods Hole, having been recorded as low as 1.0212 (March, 1908). Details of the observations on density made by the survey are presented in section I, chapter II, pages 52–54.

The lower density of the upper portion of Buzzards Bay is evidently due to the proximity of a number of small streams that empty into the head of the Bay, but these are too far removed from Woods Hole to influence materially the salinity of the water at that point. The swift tidal currents of Vineyard Sound keep its waters fairly uniform in density. It is not probable that density is a factor of importance in determining the distribution of algæ in the deeper waters of the Bay and Sound, and it certainly is not to be compared with the two chief factors of temperature and the character of the bottom.

The only bodies of brackish water in the immediate vicinity of Woods Hole are those of small ponds or areas of salt marsh which are connected with the sea by channels and rendered saline in various degrees by the inflow of tides or during storms. Such brackish waters support characteristic floras totally unlike those of the Bay and Sound proper, well illustrated by the *Lyngbya* salt-marsh association and the *Enteromorpha* salt-marsh association (see page 456).

Chapter III. CHARACTERISTIC ALGAL ASSOCIATIONS AND FORMATIONS AT WOODS HOLE AND IN BUZZARDS BAY AND VINEYARD SOUND.

As stated in the preceding pages, the life habits and distribution of marine algæ are affected by a number of factors, the most important of which are temperature, light, depth, character of the bottom, and salinity of the water. Some or all of these factors, and in special cases others as well, determine, as a rule, the habitats and seasons of the different species. As a result, various algæ are frequently found to be characteristic of particular situations, where they constitute groups or *formations* of species.

J. G. Agardh (1836) was the first to describe regions of algal vegetation, recognizing on the Scandinavian coasts the presence of a zone characterized by green algæ (*Regnum Algarum Zoospermarum*), a zone of brown algæ (*Regnum Algarum Olivacearum*), and a zone of red algæ (*Regnum Algarum Floridearum*). Other authors have attempted similar, but more elaborate, divisions of the algal flora into regions and zones, but none have been very satisfactory for the reason that the brown and red algæ have species which range far outside the depth or zone which is in general most characteristic of their class.

It later became apparent that the algæ must be split into smaller assemblages than the zones of green, brown, and red algæ, and Kjellman (1877 and 1878), also in studies on the Scandinavian coast, developed such a classification in detail, applying the name "formation" to each group and usually naming each formation after the alga most characteristic of it. Kjellman's paper of 1878, "Ueber Algenregionen und Algenformationen im östlichen Skager Rack," stands, as far as the author is aware, as the first algological contribution introducing the methods and terminology of ecology as at present practiced. Later authors have followed the methods of Kjellman to a greater or less degree, and among them one of the most elaborate studies has been that of Börgesen (1905), "The Algæ Vegetation of the Færöese Coasts." The reader will find in these two papers of Kjellman and Börgesen historical treatments of the literature, which need not be repeated here, especially since they deal with conditions in northern waters, which are very different from those at Woods Hole.

Kjellman (1877) employed the terms "littoral,"[a] "sublittoral," and "elittoral" to define three regions of distribution, and these terms are in wide use among botanists and, with certain modifications of his definitions, they have replaced earlier expressions designating regions occupied by the green, the brown, and the red algæ. Kjellman defined the littoral region as that between lowest and highest tide marks, the sublittoral region as that from the lowest tide mark to the furthest depth at which algæ will grow (about 20 fathoms on the Scandinavian coast), and the elittoral region as that bottom below the sublittoral.

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[a] Cf. discussion on pages 178–180, section 1, of present report.

Kjellman's limitation of the littoral region has not proved altogether satisfactory, since many marine algæ range far above the highest tide mark, especially along coasts wet by the spray from heavy surf, and other species are able to live in water that is brackish or, indeed, actually fresh. Rosenvinge (1898, p. 189) pointed out that the upper boundary of the littoral region should be considered as that level at which marine algal vegetation begins, and Börgesen (1905, p. 709) agrees with this view. The littoral region can then best be defined as the zone extending from low-water mark to the highest point where marine algæ cease to grow. As a matter of fact, however, in sheltered waters the upper limit will generally coincide closely with high-tide mark.

The line between the littoral and sublittoral regions is not always easily determined, for conditions vary in different localities. It is not safe to limit arbitrarily the upper boundary of the sublittoral to the lowest water or neap tide mark, for many species characteristic of the sublittoral will grow a little above such a line. Rosenvinge and Börgesen agree in placing the boundary between the littoral and sublittoral somewhat above the lowest tide mark. It is probably very near to the average low-water level.

The lower limit of the sublittoral region varies greatly in its depth from the surface and can not be defined with exactness. It merely marks the gradual diminution of vegetation until a bottom is reached that is devoid of plant life. There is no sharp line showing the lower boundary of the sublittoral, such as defines its upper limit at low-water mark. Consequently there is no line marking the upper limit of an elittoral region or depth from which plant life is absent. Indeed, to speak of an elittoral region is to use a negative expression, and the term is not important in descriptive studies on the distribution of algæ.

The line of greatest significance in determining regions of marine vegetation is that between the littoral and sublittoral, near the level of average low water. Above and below this boundary the life conditions differ more than at any other point between the upper and lower limits of marine algal life. Exposure to the air, to rain, and to the heat and drying influence of untempered sunlight introduce very important factors in the littoral region which are not present in the sublittoral and make this line of separation a most significant one. For these reasons the littoral and sublittoral regions are natural divisions, and further subdivisions are of far less import and, indeed, can hardly be made under ordinary conditions, although some authors have attempted to define a supralittoral region above the littoral.

Certain of the Cyanophyceæ and Chlorophyceæ and a few of the Phæophyceæ and Rhodophyceæ are most commonly found only in the upper region of the sublittoral either just below the lowest tide mark or in shallow water. For these a separate zone might be distinguished; but there are so many species of the Phæophyceæ and Rhodophyceæ which are present in both shallow and deep water that the limits of such a zone, at least in the Woods Hole region, is not easily determined, since there is a very complex overlapping of species. For these reasons we have not attempted to separate and designate regions of the sublittoral further than to qualify the term with the words "upper" or "lower" in certain instances where species are very clearly restricted in their habits.

When the algæ of the littoral and sublittoral regions are studied closely, certain groups of species will be found in more or less close companionship, with definite rela-

tions to such factors as proximity to low-water mark, temperature, exposure to air or to sunlight, sheltered and shaded stations, salinity of water, character of attachment, etc. These groups of species may cover large areas and even form broad zones of vegetation so clearly defined and conspicuous as to deserve the name of *formations;* but the vegetation more often consists of small and scattered groups the limits of which are generally more easily recognized and in which a single species very greatly predominates. These smaller units, usually recognized by the preponderance of a single species, are called by Börgesen (1905, p. 707) *associations*, and we shall employ that term in the brief account that follows.

The regions included in the limits of the Survey do not, on the whole, afford material for a very satisfactory study of algal associations and formations. There is nothing that compares with the picturesque zonation of algæ above and below low-water mark, as illustrated in many localities north of Cape Cod, and such as have been so thoroughly studied by Kjellman, Rosenvinge, and others along the Scandinavian coasts and in Greenland, and by Börgesen for the Faroes. The chief reasons for the comparatively undeveloped character of the formations and associations at Woods Hole and vicinity are four in number: (1) The small tides give a relatively narrow strip of coast line, generally only a few feet wide, available for the development of a littoral flora; (2) a shore line of bowlders, frequently broken by sandy or gravelly beaches, presents no smooth perpendicular or slanting surfaces where the attachment afforded to algæ is uniform in character; (3) the absence of a marked boreal flora, except for the relatively few representatives that are present chiefly in the winter and early spring, deprives the region of a number of species of *Monostroma*, *Alaria*, *Dictyosiphon*, *Fucus*, *Laminaria*, *Sacchoriza*, *Gigartina*, and *Halosaccion*, which are conspicuous north of Cape Cod; and (4) the scraping of the ice along the more sheltered shores effectually prevents the development of a littoral flora in the winter season, which is the most favorable for the growth of green and brown littoral species.

One has only to look at the remarkable plates of Börgesen (1905) illustrating the littoral algal associations and formations along the coasts of the Faroes to realize how poorly developed is the littoral flora at Woods Hole. There are also no rock pools or caverns harboring the striking assemblages of algæ characteristic of such situations. On the other hand, certain peculiarities of bottom, tidal channels, shallow harbors, and coves give conditions and resulting floras that are not present in many northern seas.

The arrangement of the associations follows in general the order of the Catalogue, where will be found the records upon which these brief accounts are based. The number of species discussed or listed is far short of the total list given in the Catalogue; they are merely those sufficiently conspicuous to be worthy of attention in a treatment of algal associations.

For descriptive purposes Buzzards Bay has been regarded in this section of the report as being divided into an upper and lower portion by a line drawn from the west end of Naushon (Robinsons Hole) to Round Hill Point. Vineyard Sound has been divided into three regions, (*a*) the westerly portion from the entrance at Gay Head to a line drawn from the west end of Naushon (Robinsons Hole) to Kopeecon Point, (*b*) the narrow portion from this line to one between Nobska Point and West Chop, and (*c*) the easterly portion from the latter line to one drawn between Falmouth Heights

and East Chop.[a] The lower portion of the Bay and the westerly portion of the Sound have in the summer a flora, here termed the cool-water sublittoral formation, with a number of striking peculiarities, while the more sheltered regions have in the summer a strictly warm-water sublittoral formation.

Only the most striking of the algal associations and formations will be described, for this is a subject which might be followed into such detail that the broad and striking peculiarities would be lost among the minor features. Moreover, for the reasons given above, the physiographical features and other conditions of Woods Hole do not lend themselves to the development of picturesque algal associations.

ALGAL ASSOCIATIONS.

(1) THE LYNGBYA SALT-MARSH ASSOCIATION.

The bottom and sides of shallow bodies of water in salt marshes, and other brackish ditches and pools, are frequently covered by felted growths, which are largely composed of *Lyngbya*, most commonly the species *L. æstuarii* and *L. semiplena*. Mixed with the Lyngbyas may be found *Chroococcus turgidus*, *Microcoleus chthonoplastes*, *Microcoleus tenerrimus*, *Spirulina subsalsa*, *Anabæna torulosa*, *Nodularia Harveyana*, and other forms.

This is a very characteristic association of blue-green algæ frequently forming extensive growths in the summer months in the salt marshes and brackish pools of Quisset, Penzance, and Hadley Harbor.

(2) THE ENTEROMORPHA SALT-MARSH ASSOCIATION.

Brackish pools in salt marshes and other situations frequently contain extensive floating or loosely attached growths, which are chiefly species of *Enteromorpha*, the commonest species being *E. clathrata*, *E. crinita*, *E. percursa*, and *E. prolifera*. *Cladophora expansa* is found under similar conditions, frequently mixed with the Enteromorphas.

This association of green algæ forms surface growths in situations where the *Lyngbya* association is likely to be found over the bottom. It is frequently conspicuous during the summer months in brackish pools of Quisset, Penzance, and Hadley Harbor.

(3) THE CALOTHRIX ASSOCIATION.

Of the four species of *Calothrix* which may be found on stones and woodwork between tide marks, *C. pulvinata* is the most conspicuous, developing thick patches resembling honeycomb on the woodwork of wharves (wharf of U. S. Bureau of Fisheries). *Calothrix scopulorum*, also conspicuous, grows on rocks near high-water mark or above, occasionally in company with *Codiolum gregarium*, forming large indefinite patches; it also grows on piles.

(4) THE RIVULARIA ASSOCIATIONS.

Rivularia nitida is found in salt marshes (as at Quisset) forming thick growths over mud and roots of *Spartina* well above low-water mark. *Rivularia atra* is occasionally plentiful on rocks and barnacles near high-water mark.

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[a] Geographically this region might be considered as a portion of Nantucket Sound if one were disposed to draw an arbitrary line between Vineyard Sound and that body of water.

(5) THE PLEUROCAPSA ASSOCIATION.

Pleurocapsa fuliginosa grows on rocks and stonework, forming a conspicuous dark stain at high-water mark and in depressions wet by waves and spray.

(6) THE ULVA, ENTEROMORPHA, AND MONOSTROMA ASSOCIATIONS.

Rocks and stony beaches above low-water mark frequently exhibit striking growths of species of *Ulva*, *Enteromorpha*, and *Monostroma*. *Ulva Lactuca* var. *rigida* is common above low-water mark on rocks exposed to waves where it frequently forms dense zones of growth. *Enteromorpha intestinalis* is often abundant in quiet waters attached to stones and shells and sometimes to woodwork of wharves between tide marks; it may develop broad zones of growth in such situations. *Enteromorpha linza* is also found in the same situations as *Enteromorpha intestinalis* and is sometimes mixed with it. *Enteromorpha minima* is very common during the spring and summer in situations similar to those of *Enteromorpha intestinalis*, but always growing near high-water mark. In the spring *Monostroma Grevillei* is abundant on stones and larger algæ a little above low-water mark.

These forms, together with certain species of *Cladophora* described in association 9, make up the most characteristic associations of green algæ in the littoral region. They are generally responsible for the conspicuous green zones on wharves, rocks, and beaches above low-water mark.

(7) THE ULOTHRIX ASSOCIATIONS.

Ulothrix flacca is not uncommon in the summer, forming large patches on stones and woodwork of wharves above low-water mark; it is sometimes epiphytic on *Fucus*. *Ulothrix implexa* is also present in the spring on rocks above low water.

(8) THE CHÆTOMORPHA ASSOCIATIONS.

Chætomorpha Linum is common growing in wiry masses over sandy and muddy bottoms. It was dredged by the Survey as deep as 5 fathoms, but is generally found in shallow water in the upper regions of both the cool- and warm-water sublittoral formations (A and B).

Chætomorpha melagonium is present in deeper water off exposed points, such as Gay Head and Cuttyhunk (chart 228). This species was dredged in 4 to 9 fathoms and is a characteristic member of what is here termed the cool-water sublittoral formation.

(9) THE CLADOPHORA ASSOCIATIONS.

Several species of *Cladophora* develop conspicuous associations in the upper level of the sublittoral region. *Cladophora albida* and *C. albida* var. *refracta* form in the summer patches on rocks. *Cladophora arcta* is very abundant in the spring on wharves and harbor walls near low-water mark and below, and is one of the most characteristic of the green algæ at that season. *C. flexuosa* is common in the summer on rocks, and *C. glaucescens*, a delicate species, is also abundant at the same season on rocks and wharves near low-water mark. *C. gracilis* grows luxuriantly during the summer in quiet sheltered waters. *C. lanosa* is epiphytic on larger algæ generally below low water; *C. lanosa* var.

uncialis grows on rocks above and below low-water mark and is conspicuous in the winter and spring. *C. refracta* and *C. Rudolphiana* are frequently abundant on stones near low water and below. *C. rupestris* is a striking species growing off exposed points as at Nobska and Gay Head.

The list of *Cladophoras* in this region is large, but they are apt to grow mixed with other algæ. However, *C. albida, C. albida* var. *refracta, C. arcta, C. gracilis,* and *C. lanosa* var. *uncialis* frequently form extensive and almost pure growths, which are as conspicuous as the zones of *Ulva, Enteromorpha,* and *Monostroma.*

(10) THE VAUCHERIA ASSOCIATIONS.

Vaucheria litorea and *V. Thuretii* are occasionally found forming rather extensive and sometimes matted growths over gravel and mud near low-water mark and below.

(11) THE ECTOCARPUS ASSOCIATIONS.

Most of the species of *Ectocarpus* grow attached to larger algæ or to *Zostera,* but some are found on stones and the woodwork of wharves near low-water mark and below. *Ectocarpus confervoides* and *E. siliculosus* are frequently present in the latter situations, forming at times extensive growths. Some of the epiphytic species may grow so thickly over such forms as *Scytosiphon lomentarius, Desmarestia aculeata, Chordaria flagelliformis, Chorda filum, Laminaria Agardhii,* and *Zostera* as to form a conspicuous part of the associations that contain these larger algæ and the eel grass. The commonest of the epiphytic species are *Ectocarpus œcidioides* on old *Laminaria, E. confervoides* on *Scytosiphon* and *Chordaria, E. fasiculatus* on *Chordaria* and *Chorda, E. granulosus* on *Sargassum, E. penicillatus* on larger algæ and *Zostera,* and *E. siliculosus* on *Scytosiphon, Zostera,* etc.

(12) THE CLADOSTEPHUS ASSOCIATION.

Cladostephus verticillatus grows in fairly deep water and has a scattered distribution in Vineyard Sound (chart 229). It was dredged in 2 to 13 fathoms over sandy and stony bottoms. Although not plentiful, this species is conspicuous for its size; it is a member of the warm-water sublittoral formation (B).

(13) THE SPHACELARIA ASSOCIATIONS.

Sphacelaria cirrhosa is epiphytic on *Fucus, Ascophyllum, Sargassum,* and occasionally on *Zostera;* it may also grow on stones. The species is probably widely distributed along the coast and was dredged in 3 to 8 fathoms on *Sargassum* and stones at several scattered stations in Vineyard Sound.

Sphacelaria radicans is common attached to stones, shells, and mud-covered rocks. It was dredged in 3 to 5 fathoms, chiefly at stations near Vineyard Haven.

The two species are in the warm-water sublittoral formation (B).

(14) THE DESMOTRICHUM AND PUNCTARIA ASSOCIATIONS.

Desmotrichum balticum and *D. undulatum* are common, especially in the spring, forming dense growths on *Zostera;* they are occasionally found on larger algæ and on rocks.

Punctaria latifolia and *P. plantaginea* are likewise common in the spring, the former on *Zostera* and larger algæ, the latter on algæ and rocks.

(15) THE PHYLLITIS AND SCYTOSIPHON ASSOCIATIONS.

Phyllitis fascia is common in the winter and spring on rocks just below low-water mark and in the littoral region. *Scytosiphon lomentarius* is also abundant in similar situations on rocks, and also on stony beaches, where it develops extensive growths during the winter and spring extending above the *Phyllitis* in the littoral region.

These two algæ, so conspicuous in the littoral during the winter and spring, practically disappear during the summer, being then found only in very favorable situations, as, for example, at Gay Head and at Grassy Ledge, in Woods Hole Harbor, on the side of the ship channel. They frequently form a mixed association, but *Scytosiphon* is the commoner of the two and more widely distributed.

(16) THE ARTHROCLADIA ASSOCIATION.

Arthrocladia villosa, which has been considered rather rare, was found by the Survey to be widely distributed in Buzzards Bay and Vineyard Sound (chart 230). Although generally dredged in small quantities, it was obtained in abundance in the cove west of Cuttyhunk Neck (near station 101) July 27, 1905. At this date large plants in full fruit grew on shells and stones in 4 to 5 fathoms, forming large patches over the bottom. The species is a member of the warm-water sublittoral formation (B).

(17) THE DESMARESTIA ASSOCIATION.

Desmarestia aculeata is a large coarse species plentiful in the lower portion of Buzzards Bay and westerly portion of Vineyard Sound (chart 231). It grows over sandy and stony bottoms in 1½ to 14 fathoms. Although the plants are more often scattered, they sometimes form patches which would be considered as associations. The species is frequently a member of the cool-water sublittoral formation (A).

Desmarestia viridis is found not only in the same situations as *D. aculeata*, but also in quieter and warmer regions of the Sound (chart 232). It is common at Woods Hole in the spring and early summer, a little below low-water mark. The growths are generally scattered, but they may also form dense associations. This species is a member of the warm-water sublittoral formation (B), but is also present in colder waters, although not so common there as *Desmarestia aculeata*.

(18) THE DICTYOSIPHON ASSOCIATION.

A species of *Dictyosiphon* is present during the summer months rather widely distributed in both Bay and Sound on stones and over sand in 3 to 10 fathoms (chart 233). The form compares well with material and descriptions of *Dictyosiphon hippuroides*. However, in view of the difficulties in determining species in this genus and the fact that our material was evidently a summer seasonal condition, we do not feel sure of its affinities. It was found at several stations in sufficient quantity to constitute associations, and is present in both the cool- and warm-water sublittoral formations.

(19) THE CASTAGNEA ASSOCIATION.

Castagnea Zosteræ is common at Woods Hole in the summer, attached to *Zostera* *Castagnea virescens* is occasionally found on rocks, *Zostera*, and larger algæ below low-water mark. Both species are present in the warm-water sublittoral formation (B), but *C. virescens* is also a spring species.

(20) THE CHORDARIA ASSOCIATION.

Chordaria flagelliformis during the summer develops extensive growths on stones and rocks a little below low-water mark. It grows in large masses and is frequently the most conspicuous member of the zone of brown algæ, fringing exposed rocks near low-water mark. The other prominent members of this zone are commonly *Phyllitis fascia* and *Scytosiphon lomentarius*, which grow above the *Chordaria* and in the littoral region. The *Chordaria* is frequently overgrown with *Ectocarpus confervoides*, *E. fasiculatus* or *E. siliculosus*, and it also harbors *Callithamnion Baileyi*, *C. corymbosum*, and other algal epiphytes.

(21) THE MESOGLOIA ASSOCIATION.

Mesogloia divaricata grows in masses on stones and algæ in relatively quiet waters a little below low-water mark. It is a conspicuous summer plant occupying a situation somewhat similar to that of *Chordaria flagelliformis* in more exposed situations.

(22) THE RALFSIA ASSOCIATIONS.

Ralfsia clavata is very abundant on stones and shells at low-water mark and below. It is widely distributed throughout the sublittoral region at Woods Hole and in the Bay and Sound, and has been dredged in 3 to 12 fathoms. *Ralfsia verrucosa* is less widely distributed, but in certain localities has been found in quantity (Grassy Ledge, Little Harbor, Tarpaulin Cove); it grows on stones near low-water mark.

(23) THE CHORDA ASSOCIATION.

Chorda filum is a summer species very common in the sublittoral region on stones and shells in water 3 feet or more in depth. It frequently forms large beds and sometimes supports extensive epiphytic growths of *Ectocarpus fasiculatus*, *Ceramium rubrum*, and other species. *Chorda filum* is widely distributed throughout the Bay and Sound (chart 234) and was dredged in 2 to 14 fathoms.

Chorda tomentosa is a very beautiful spring species common at Woods Hole in the same situation as *Chorda filum*, which takes its place later in the season. We know nothing of its distribution in Buzzards Bay and Vineyard Sound.

(24) THE LAMINARIA ASSOCIATIONS.

The genus *Laminaria* has only three representatives in the waters of Buzzards Bay and Vineyard Sound. In comparison with the flora north of Cape Cod the kelps play but an insignificant part in the vegetation of this region.

Laminaria Agardhii is rather widely distributed (chart 235), being common at Woods Hole on wharves and stones in water 3 feet or more in depth; it was dredged over sandy, shelly, and stony bottoms in 2 to 17 fathoms.

Laminaria Agardhii var. *vittata* is restricted in its distribution chiefly to the lower portion of the Bay and westerly portion of the Sound (chart 236); it grows over sandy, shelly, and stony bottoms in 2 to 17 fathoms, sometimes forming beds of considerable extent frequently mixed with *Laminaria Agardhii*.

Laminaria digitala was found only off Gay Head (chart 237) over sandy and stony bottoms in 3 to 13 fathoms, accompanied by the other forms of *Laminaria*. All of these kelps are characteristic members of the cool-water sublittoral formation (A), but *Laminaria Agardhii* is more widely distributed than the others.

(25) THE FUCUS AND ASCOPHYLLUM ASSOCIATIONS.

Ascophyllum nodosum and *Fucus vesiculosus* are the only rockweeds that develop extensive associations in these waters; the other two species of *Fucus* do not form very conspicuous growths.

Ascophyllum nodosum grows plentifully over rocks near low-water mark and above in somewhat sheltered situations. It is found in its best vegetative condition during the winter snd spring culminating with the fruiting period in May; the summer growth is somewhat dwarfed and much lighter in color (yellowish) where exposed to bright sunlight.

Fucus vesiculosus, with its several forms and varieties, is more plentiful than *Ascophyllum*, growing over a wide zone from below low-water mark to a high point in the littoral region. It is likewise found in its best vegetative condition during the winter and spring, fruiting most abundantly in the latter season. It is represented during the summer by dwarfish growths, frequently lighter in color than the winter condition, except off exposed points as at Gay Head, where the growth and fruiting is more uniform.

The *Ascophyllum* and *Fucus* frequently form a mixed association at Woods Hole, which during the winter develops a broad zone in the littoral region over rocks that are not subjected to severe scraping by the ice. Most of the winter growths matures during the spring and the display during the summer is comparatively poor.

(26) THE SARGASSUM ASSOCIATION.

Sargassum Filipendula is common during the summer in the warmer and more sheltered regions of the Bay and Sound (chart 238); it was dredged over sandy, shelly, and stony bottoms in 2½ to 15 fathoms, sometimes froming rather large beds. At Woods Hole there are conspicuous associations at the entrance to the Eel Pond and off Juniper Point, where the plants grow in large patches in 3 feet to 1 or more fathoms of water. *Sargassum* is thus strictly sublittoral, in sharp contrast to the habits of the species of rockweeds, and it is characteristic of the warm-water sublittoral formation (B).

(27) THE BANGIA ASSOCIATION.

Bangia fusco-purpurea is not uncommon, forming patches on rocks and woodwork of wharves near high-water mark. *Ulothrix flacca* is frequently mixed to a greater or less degree with the *Bangia*.

(28) THE PORPHYRA ASSOCIATION.

Porphyra laciniata frequently develops heavy growths on the harbor walls at Woods Hole near low-water mark. *Porphyra leucosticta* is a spring species common on larger algæ and on *Zostera*.

(29) THE CHANTRANSIA ASSOCIATIONS.

Chantransia virgatula is abundant, fringing the leaves of *Zostera*, and is a conspicuous member of the *Zostera* formation (C). *Chantransia secundata* is sometimes common on *Zostera*, *Ceramium rubrum*, and *Porphyra laciniata*. *Chantransia Thuretii* is occasionally found in quantity on *Ceramium rubrum* and on *Cystoclonium purpurascens* at a depth of 1 to 3 meters (off Juniper Point).

(30) THE NEMALION ASSOCIATION.

Nemalion multifidum is a very characteristic summer species, frequently forming a broad zone on rocks a little above low-water mark. This is, perhaps, the best illustration of a red alga with life habits in this region apparently demanding a certain degree of exposure to the air.

(31) THE ANTITHAMNION ASSOCIATION.

Antithamnion cruciatum proved to be very widely distributed during the summer in Vineyard Sound and Buzzards Bay, attached to stones and larger algæ in 3 to 15 fathoms (chart 239). It frequently forms dense epiphytic growths on *Chondrus*, *Phyllophora*, and *Polyides*. The species is a common member of the warm-water sublittoral formation (B), but it is also found in exposed situations, as off Gay Head and Cuttyhunk. The other species of *Antithamnion* are not found in sufficient quantity to form conspicuous associations.

(32) THE CALLITHAMNION ASSOCIATIONS.

Of the five species of *Callithamnion* found in this region only three forms develop growths so extensive as to be worthy of consideration in this connection.

Callithamnion roseum is common during the summer in the more sheltered waters of the Bay and Sound, growing on stones, shells, larger algæ, and *Zostera* in 3 to 13 fathoms. It is especially abundant in the easterly portion of Vineyard Sound, where *Chondrus*, *Phyllophora*, and *Sargassum* frequently support heavy epiphytic growths. The species is a characteristic member of the warm-water sublittoral formation (B).

Callithamnion Baileyi and *C. Baileyi* var. *laxum* are also common during the summer, but generally only as scattered plants. *Callithamnion Baileyi* grows on rocks, and is also frequently epiphytic on larger algæ, such as *Chordaria* and *Ceramium rubrum*, in the upper level of the sublittoral. It was dredged in 3 to 13 fathoms attached to *Desmarestia*, *Chondrus*, *Phyllophora*, and *Cystoclonium*. The species seems to prefer the conditions of the warm-water sublittoral formation.

(33) THE CERAMIUM ASSOCIATIONS.

Of the six species of *Ceramium* present in these waters, *C. rubrum* deserves the most attention, on account of its abundance and very wide range (chart 240). This species is conspicuous in the upper level of the sublittoral, as one of the commonest members of the zone of red algæ frequently found on rocks a little below low-water mark in company with such forms as *Polysiphonia fibrillosa*, *P. urceolata*, *P. violacea*, and *Chondrus crispus*. *Ceramium rubrum* is also abundant in deeper water, and was

dredged in 1 to 19 fathoms attached to stones. It is a very common epiphyte on *Chorda*, *Chondrus*, and *Phyllophora*, and on *Zostera*. The species is present in both the cool and warm-water sublittoral formations.

Ceramium fastigiatum is frequently abundant on *Zostera* and on larger algæ, such as *Phyllophora*, and sometimes on stones; it was dredged in 2 to 7 fathoms. *Ceramium strictum* and *C. tenuissimum* are also common on *Zostera* and on larger algæ, and occasionally on stones; they were dredged in 2 to 15 fathoms. These three species have a scattered and probably wide distribution in sheltered regions of the Bay and Sound, but are not present in abundance; they belong to the warm-water sublittoral formation (B).

(34) THE GRIFFITHSIA ASSOCIATIONS.

Griffithsia Bornetiana is common in the summer in the more sheltered portions of the Bay and Sound (chart 241). The species is an epiphyte on larger algæ, such as *Chondrus* and *Phyllophora*, and was dredged in 2 to 15 fathoms (most plentiful between 3 and 6 fathoms); it is a conspicuous member of the warm-water sublittoral formation (B).

Griffithsia tenuis has a distribution restricted to the extreme upper portion of Buzzards Bay (chart 242), where it may be found in large patches loosely attached over sandy and muddy bottoms in 2 to 4 fathoms. It is a striking species in these sheltered regions (that support comparatively little algal vegetation), evidently preferring warm waters.

(35) THE PLUMARIA ASSOCIATION.

Plumaria elegans is restricted to exposed situations, such as Gay Head and Sow and Pigs (chart 243). There it is abundant as an epiphyte on *Chondrus* and *Phyllophora* over sandy and stony bottoms in 3 to 17 fathoms. It is one of the most characteristic species of the cool-water sublittoral formation (A).

(36) THE SEIROSPORA ASSOCIATION.

Seirospora Griffithsiana is sometimes very common on stones, shells, *Zostera*, and larger algæ in 3 to 10 fathoms. It has a scattered distribution in both Bay and Sound, and is frequently present in the warm-water sublittoral formation (B).

(37) THE SPERMOTHAMNION ASSOCIATION.

Spermothamnion Turneri is very abundant as an epiphyte on such algæ as *Chondrus*, *Phyllophora*, and *Polyides* in 1 to 17 fathoms, over sandy, shelly, stony, and muddy bottoms. It is distributed widely in the Bay and Sound (chart 244) and is present in both the cool- and warm-water sublittoral formations.

(38) THE SPYRIDIA ASSOCIATIONS.

Spyridia filamentosa is very widely distributed in both Bay and Sound (chart 245); it is found on stones and shells, frequently over muddy bottoms, and on *Zostera* and larger algæ, and was dredged in 3 to 15 fathoms (most plentiful in 4 to 10 fathoms). The species is a characteristic member of the warm-water sublittoral formation (B).

(39) THE CHONDRIA ASSOCIATIONS.

Chondria tenuissima is abundant on rocks and larger algæ below low-water mark along somewhat sheltered shores; it was dredged as deep as 2 to 5 fathoms at Phalarope station 73, but the species is on the whole rather characteristic of the upper level of the sublittoral region. *Chondria tenuissima* var. *Baileyana* is less common, but found in similar situations.

Chondria dasyphylla is also found on rocks and larger algæ and sometimes on *Zostera* below low-water mark. It is a coarse species, generally present in less sheltered situations than *Chondria tenuissima* and was dredged in 4 to 10 fathoms, chiefly in the easterly portion of Vineyard Sound. *Chondria sedifolia* is closely related to *C. dasyphylla*, and has been classed as a variety of the latter; it is less common, but is found in similar situations.

All the species of *Chondria* are members of the warm-water sublittoral formation (B), preferring shallow water and sheltered situations.

(40) THE DASYA ASSOCIATION.

Dasya elegans is very abundant during the late summer below low-water mark, generally in sheltered situations on *Zostera*, on larger algæ, and occasionally on stones; it was dredged over sandy and stony bottoms in 2 to 13 fathoms and has a wide and scattered distribution throughout the Bay and Sound. The species is a member of the warm-water sublittoral formation (B) and is also frequently conspicuous in the *Zostera* formation (C).

(41) THE POLYSIPHONIA ASSOCIATIONS.

Of the 12 species of *Polysiphonia* found in this region 8 are sufficiently common to present conspicuous associations.

Polysiphonia elongata, the largest species, grows on stones and rocks in fairly deep water over sandy, shelly, and stony bottoms in 2 to 17 fathoms (most plentiful in 5 to 13 fathoms). The species is common and widely distributed throughout Vineyard Sound, but is found only in the lower portion of the Bay (chart 246). It is present in both the warm- and cool-water sublittoral formations, but is more plentiful in the latter.

Polysiphonia fibrillosa is common at Woods Hole in the summer, frequently forming a zone on rocks at and just below low-water mark. Although characteristic of the upper region of the warm-water sublittoral, the species was dredged at several scattered stations in Vineyard Sound in 2 to 11 fathoms.

Polysiphonia Harveyi and *P. Olneyi* form tufted growths on eel grass in quiet water, and are members of the *Zostera* formation (C).

Polysiphonia nigrescens is very abundant on stones and shells frequently over muddy bottoms in 1 to 15 fathoms (most plentiful in 5 to 10 fathoms). The species is widely distributed in both Bay and Sound (chart 247), and is present in both the cool- and warm-water sublittoral formations.

Polysiphonia urceolata is abundant in the spring and very conspicuous in the zone of red algæ on stones and wharves below low-water mark. The species at that season is probably widely distibuted in both the Bay and Sound and is then a prominent mem-

ber of the cool-water sublittoral formation; it was dredged in the summer in the lower portion of Buzzards Bay in 2 to 19 fathoms.

Polysiphonia variegata is common in the summer on stones, *Zostera*, and larger algæ, and also grows loosely attached over sand and mud in sheltered situations; it was dredged in 3 to 6 fathoms in the upper portion of Buzzards Bay (chart 248). The species belongs to the warm-water sublittoral formation, preferring sheltered situations.

Polysiphonia violacea is abundant in the summer on stones, rocks, and on the larger algæ below low-water mark; it was dredged in 1 to 13 fathoms over sandy and stony bottoms and has a wide though scattered distribution in the Bay and Sound. The species is an important member of the zone of red algæ below low-water mark on rocks in exposed situations, taking the place which *P. urceolata* occupies in the spring. It belongs to the warm-water sublittoral formation.

(42) THE RHODOMELA ASSOCIATIONS.

Rhodomela Rochei and *R. subfusca* are probably very abundant in the spring throughout the Bay and Sound. The bases of old plants were dredged during the summer at scattered stations in 3 to 8 fathoms for *Rhodomela Rochei*, and 3 to 12 fathoms for *R. subfusca*. In the spring these species are undoubtedly conspicuous members of the cool-water sublittoral formation (A).

(43) THE AHNFELDTIA ASSOCIATION.

Ahnfeldtia plicata is common in exposed situations as off Gay Head and Cuttyhunk (chart 249). It was dredged in 1 to 14 fathoms (most plentiful in 7 to 13 fathoms) over sandy, shelly, and stony bottoms, and is one of the cool-water sublittoral species.

(44) THE CHONDRUS ASSOCIATION.

Chondrus crispus, the Irish moss, is abundant along the shores of the Bay and Sound below low-water mark; it was dredged in 1 to 19 fathoms (most plentiful in 4 to 12 fathoms) over sandy, shelly, and stony bottoms. The species is widely distributed through the Bay and Sound (chart 250), wherever the bottom is favorable, and grows in dense patches on the rocks. It does not as a rule come so close to the surface as *Ceramium rubrum*, *Polysiphonia fibrillosa*, *P. urceolata*, and *P. violacea*, but it is the most conspicuous member on exposed rocks of the zone of red algæ somewhat below these species. *Chondrus crispus* is a very important member of both the cool and warm-water sublittoral formations, with preferences for the former; for, although enduring the warm water of the summer, it grows most luxuriantly in colder temperatures.

(45) THE PHYLLOPHORA ASSOCIATIONS.

The two species of *Phyllophora* have very similar life habits; they are rarely found in the upper level of the sublittoral region and are generally present only at a considerable depth.

Phyllophora Brodiæi grows on stones and in sand and mud and was dredged in 1½ to 15 fathoms (most plentiful in 4 to 10 fathoms). It is distributed very generally

throughout the Bay and Sound (chart 251), but is most abundant off exposed situations, as at Gay Head and Cuttyhunk, where extensive growths are present.

Phyllophora membranifolia is also found on stones and over sand and mud; it was dredged in 3 to 17 fathoms (most plentiful in 4 to 10 fathoms). The species is likewise distributed very generally throughout the Bay and Sound (chart 252), but appears to prefer rather more sheltered situations than *Phyllophora Brodiæi.*

Both species of *Phyllophora* are prominent in the cool- as well as the warm-water sublittoral formations.

(46) THE AGARDHIELLA ASSOCIATION.

Agardhiella tenera is very common on stones and shells in fairly deep water; it grows in 2 to 15 fathoms (most plentiful in 4 to 10 fathoms). The species is very widely distributed throughout both the Bay and Sound (chart 253), but prefers rather sheltered waters and is a characteristic member of the warm-water sublittoral formation (B), where it is commonly associated with *Grinnellia americana.*

(47) THE CYSTOCLONIUM ASSOCIATIONS.

Cystoclonium purpurascens has a scattered distribution in both Bay and Sound (chart 254). It was found in 2½ to 13 fathoms (most plentiful in 4 to 10 fathoms) attached to stones over sandy, shelly, and stony bottoms, occasionally over mud. The species rarely forms extensive patches but is conspicuous because of its large size; it is found in both the cool- and warm-water sublittoral formations.

Cystoclonium purpurascens var. *cirrhosum* is abundant in the lower portion of the Bay and westerly portion of the Sound (chart 255). It was dredged in 1 to 17 fathoms (most plentiful in 4 to 12 fathoms) attached to stones and to larger algæ over a bottom similar to that of the preceding species. The variety is much more luxuriant than the species and frequently forms large patches of vegetation; it clearly prefers the conditions of the cool-water sublittoral and is a prominent member of that formation (A).

(48) THE CHAMPIA ASSOCIATION.

Champia parvula is one of the most widely distributed algæ of the region, occasionally forming extensive patches in the Bay and Sound (chart 256). It grows in 1 to 19 fathoms (most plentiful in 4 to 12 fathoms) attached to stones, *Zostera*, and larger algæ, over sandy, shelly, stony, and muddy bottoms; it is frequently found in shallow water along the shore. The species belongs to the warm-water sublittoral formation (B), being found most abundantly in sheltered regions.

(49) THE LOMENTARIA ASSOCIATIONS.

Lomentaria rosea is found only off the exposed points of Gay Head and Cuttyhunk (chart 257). It was dredged in 4 to 13 fathoms on stones, shells, and on larger algæ, over sandy, shelly, and stony bottoms. The species is restricted to the cool-water sublittoral and although never abundant is one of the most characteristic members of this formation (A).

Lomentaria uncinata grows in the sheltered waters of the Bay and Sound (chart 258). It was dredged in 1½ to 15 fathoms (most plentiful in 4 to 10 fathoms) over sandy,

shelly, and stony bottoms, and it is also abundant in shallow water along shore. In sharp contrast to *L. rosea*, this species is characteristic of the warm-water sublittoral formation (B) and prefers sheltered situations where it frequently accompanies *Champia parvula.*

(50) THE RHODYMENIA ASSOCIATION.

Rhodymenia palmata, the dulse, is found chiefly in the lower portion of Buzzards Bay and westerly portion of Vineyard Sound (chart 259). It was dredged in 1 to 19 fathoms (most plentiful in 4 to 12 fathoms) growing on stones and larger algæ, over sandy, shelly, and stony bottoms. A prominent member of the cool-water sublittoral formation (A), this large species is conspicuous for its size, although the growths in this region are never extensive.

(51) THE DELESSERIA ASSOCIATION.

Delesseria sinuosa is practically restricted to the lower portion of the Bay and westerly portion of the Sound (chart 260). It grows on larger algæ, such as *Chondrus* and *Phyllophora*, occasionally on stones, and was dredged in 1½ to 17 fathoms (most plentiful in 4 to 12 fathoms). The species is a member of the small group of algæ peculiar to the exposed conditions off Gay Head and Cuttyhunk, and is one of the noteworthy forms in the cool-water sublittoral formation (A).

(52) THE GRINNELLIA ASSOCIATION.

Grinnellia americana is almost universally distributed throughout the Bay and Sound (chart 261). It was dredged in 2 to 19 fathoms (most plentiful in 4 to 12 fathoms) on stones and shells, over sandy, shelly, stony, and muddy bottoms, but it likewise comes close to the surface, as on piles of wharves (Little Harbor, Woods Hole). Although apparently in all regions of the sublittoral, this species is partial to the more sheltered situations, and consequently warmer waters, where it is one of the most characteristic and abundant forms together with *Agardhiella tenera* and *Champia parvula.*

(53) THE POLYIDES ASSOCIATION.

Polyides rotundus, although never abundant, has a rather wide distribution in both the Bay and Sound (chart 262). It is found only in fairly deep water, 1½ to 15 fathoms (most plentiful in 4 to 10 fathoms), over sandy, shelly, and stony bottoms, occasionally over mud. The species is a member of both the cool- and warm-water sublittoral formations, and is conspicuous for its size, although the plants grow in scattered groups.

(54) THE CORALLINA ASSOCIATION.

Corallina officinalis grows in dense patches over rocks in exposed situations below low-water mark and to a considerable depth; the species is widely distributed in the more open portions of the Bay and Sound (chart 263). It was dredged in 4 to 10 fathoms, over sandy, shelly, and stony bottoms. The associations of *Corallina* are generally so dense that they occupy the surface of their attachment to the almost complete exclusion of other algæ; the species is present in both the cool- and warm-water sublittoral formations.

(55) THE HILDENBRANDIA ASSOCIATION.

Hildenbrandia prototypus is common on stones and rocks near low-water mark and extending into deep water, where it grows in 1½ to 14 fathoms (most plentiful in 4 to 10 fathoms); it is widely distributed in the Bay and Sound (chart 264). The species is found in both the cool- and warm-water sublittoral formations.

(56) THE LITHOTHAMNION ASSOCIATION.

Lithothamnion polymorphum grows on stones and shells in fairly deep water and is rather widely distributed in the Bay and Sound (chart 265). It was dredged in 2 to 15 fathoms (most plentiful in 4 to 10 fathoms) over sandy, shelly, and stony bottoms. *Lithothamnion*, although never found in abundance, is present in both the cool- and warm-water sublittoral formations.

(57) THE MELOBESIA ASSOCIATIONS.

Melobesia farinosa is fairly common on *Fucus vesiculosus*, *Chondrus*, *Phyllophora*, and *Zostera* at low-water mark and below, being dredged in 3½ to 11½ fathoms, at scattered stations in the Sound. The species is a member of the warm-water sublittoral formation.

Melobesia Lejolisii is very abundant on *Zostera* throughout the Bay and Sound in both shallow and deep water; it was dredged in 2 to 12½ fathoms. The species prefers rather sheltered waters, where it may cover the eel grass with a thin incrustation; it is characteristic of the *Zostera* formation.

Melobesia membranacea is occasionally found on *Chondrus* and *Phyllophora*, generally in exposed situations as off Gay Head, Cuttyhunk, and Penikese. It was dredged in 3½ to 10 fathoms and clearly belongs to the cool-water sublittoral formation.

Melobesia pustulata is common on *Ascophyllum*, *Chondrus*, and *Phyllophora*, and is present in both shallow and deep water, being dredged in 1½ to 14 fathoms off Gay Head, Cuttyhunk, and in the easterly portion of the Sound. The species has a scattered and probably rather general distribution along the shore and is a member of both the cool- and warm-water sublittoral formations.

THE COOL-WATER SUBLITTORAL FORMATION.

The cool-water sublittoral formation of the summer contains a number of very interesting and characteristic algæ, some of which are limited in their distribution to the exposed waters off Gay Head and the reefs of Sow and Pigs. Other species have a more extended range throughout the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound. Finally there is a group of species which, while most abundant in the regions described above, are also found in other portions of the Bay and Sound, where they form a part of the sublittoral flora characteristic of these more sheltered, and in the summer, warmer waters.

The species in these lists preceded by an asterisk (*) are the larger or more abundant forms which dominate the formation; species which are rare or occasional are followed by an (o).

The most interesting and noteworthy species in this formation are those which are especially characteristic of the cold waters north of Cape Cod and have been recorded only

south of the cape in exposed situations where they may be expected to find conditions approaching those of the north coast. The list is as follows:

*Chætomorpha melagonium.
*Laminaria digitata.
*Plumaria elegans.
Rhodomela subfusca.
Actinococcus peltæformis (o).
Gymnogongrus norvegicus (o).
Euthora cristata (o).
*Lomentaria rosea.
*Rhodymenia palmata.
*Delesseria sinuosa.
Melobesia membranacea (o).

Another group of species comprises those which range both north and south of Cape Cod; many of them are conspicuous in the warm-water sublittoral formation (B). The following are prominent:

Chætomorpha linum.
Cladophora albida var. refracta.
C. gracilis.
C. rupestris.
Ectocarpus confervoides.
E. fasciculatus.
E. siliculosus.
*Desmarestia aculeata.
*D. viridis.
*Dictyosiphon hippuroides.
*Chordaria flagelliformis.
Leathesia difformis.
*Ralfsia clavata.
Chorda filum.
*Laminaria Agardhii.
*L. Agardhii var. vittata.
*Ceramium rubrum.
Polysiphonia atrorubescens (o).
*P. elongata.
*P. nigrescens.
P. nigrescens var. fucoides (o).
P. urceolata.
Actinococcus subcutaneus.
*Ahnfeldtia plicata.
*Chondrus crispus.
*Phyllophora Brodiæi.
*Phyllophora membranifolia.
Agardhiella tenera.
*Cystoclonium purpurascens.
*Cystoclonium purpurascens var. cirrhosum.
Grinnellia americana.
Polyides rotundus.
Corallina officinalis.
Hildenbrandia prototypus.
Lithothamnion polymorphum.
Melobesia membranacea.
M. pustulata.

Finally there is a group of species which are widely distributed in the warm-water sublittoral. Chief among them are—

Cladostephus verticillatus.
*Antithamnion cruciatum.
*Spermothamnion Turneri.
Rhodomela Rochei.

The lists of species in the genera *Cladophora* and *Ectocarpus* are undoubtedly far from complete, for studies at other seasons of the year would be expected to give many additions. It must be remembered that we know nothing of this formation in the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound in the winter and spring when the conditions are much more favorable for the support of a cool-water sublittoral flora.

The chief factor which determines the cool-water sublittoral formation is the relatively low temperature of the bottom water during the summer months. The records of the temperatures off Gay Head and Cuttyhunk for the summer, as well as for other seasons of the year, are presented in a table on page 450, to which the reader is referred. It is probable that the lowest winter temperatures of the bottom water at these points fall somewhat below 35°, and that the highest summer temperatures are close to 60°. This represents about the yearly range of the bottom temperatures off the exposed points of Gay Head and Sow and Pigs, and in general of the extreme westerly portion of Vineyard Sound and the deeper water of the lower portion of Buzzards Bay. The cool-water sublittoral formation may then be said to endure a maximum temperature of about 60° for a short period in midsummer, but to live for most of the year at temperatures considerably lower. Its most favorable temperature is perhaps close to 50° or below. Whether essentially the same formation is present during the winter is not known, but it seems very probable.

THE WARM-WATER SUBLITTORAL FORMATION.

A characteristic warm-water sublittoral formation is present during the summer in the more sheltered regions of the Bay and Sound—that is, in the upper portion of Buzzards Bay and in the narrow and easterly portions of Vineyard Sound. The conditions in these regions are much more varied than in the lower portion of the Bay and the westerly portion of the Sound occupied by the cool-water sublittoral formation. For example, the conditions and flora of the upper end of Buzzards Bay are quite different from those around Woods Hole. Further subdivisions of the warm-water sublittoral formation could undoubtedly be made to advantage, but it would be unwise to attempt to do so on our present information. Accordingly, we shall treat the warm-water sublittoral as a very large and widely distributed formation, excluding, however, those algæ which are characteristically associated with beds of *Zostera* in an assemblage called here the *Zostera* formation (c).

The species in these lists (as in those of the cool-water sublittoral formation) preceded by an asterisk (*) are the larger or more abundant forms which dominate the formation; species which are rare or occasional are followed by an (o).

The most interesting and noteworthy species in the warm-water sublittoral formation are those which have not been reported at all north of Cape Cod or are present there only under exceptional conditions. This list includes the following species:

Cladophora albida.
Ectocarpus granulosus var. tenuis (o).
E. lutosus (o).
E. Mitchellæ (o).
Cladostephus spongiosus (o).
*C. verticillatus.
Rhadinocladia Farlowii (o).
Striaria attenuata (o).
*Arthrocladia villosa.
Elachista stellaris var. Chordæ (o).
Myriactis pulvinata var. minor.
Stilophora rhizodes (o).
Sargassum bacciferum (o, floating in Sound).
*S. Filipendula.
S. Filipendula var. subedentatum.
Scinaia furcellata.
*Antithamnion cruciatum.
A. cruciatum var. radicans (o).
A. plumula (o).
Callithamnion Baileyi var. laxum.
*C. roseum.
C. tetragonum.
Ceramium botryocarpum (o).
C. capri-cornu (o).
*C. tenuissimum.
*Griffithsia tenuis.
Pleonosporium Borreri.
*Seirospora Griffithsiana.
*Spermothamnion Turneri.
*Spyridia filamentosa.
Chondria dasyphylla.
C. sedifolia (o).
*Polysiphonia fibrillosa.
P. vestita (o).
Rhodomela Rochei.
R. virgata (o).
Actinococcus aggregatus (o).
Gymnogongrus Griffithsiæ (o).
Gracilaria confervoides (o).
G. multipartita.
G. multipartita var. angustissima (o).
Hypnea muciformis.
Lithothamnion polymorphum.

Another group of species comprises those which range both north and south of Cape Cod, some of them being also conspicuous in the cool-water sublittoral formation (A). The list includes the following:

Chætomorpha linum.
Cladophora albida var. refracta.
C. arcta.
C. glaucescens.
C. gracilis.
C. hirta (o).
C. lanosa.
C. Rudolphiana.
C. rupestris.
Bryopsis hypnoides (o).
B. plumosa (o).
*Ectocarpus confervoides.
*E. fasciculatus.
E. granulosus.
*E. siliculosus.
E. siliculosus var. hiemalis (o).
Pylaiella littoralis.
Sphacelaria cirrhosa.
S. radicans.
Punctaria plantaginea (o).
Desmarestia aculeata (o).
*Desmarestia viridis.
Dictyosiphon hippuroides.
Myriotrichia filiformis.

Castagnea virescens.
*Chordaria flagelliformis.
*Leathesia difformis.
*Mesogloia divaricata.
*Ralfsia clavata.
*Chorda filum.
Laminaria Agardhii.
Laminaria Agardhii var. vittata (o).
Antithamnion americanum (o).
Callithamnion Baileyi.
C. byssoideum.
C. corymbosum.
*Ceramium rubrum.
*C. strictum.
*Griffithsia Bornetiana.
*Chondria tenuissima.
C. tenuissima var. Baileyana.
*Dasya elegans.
Polysiphonia elongata.
P. fastigiata (o).
*P. nigrescens.
*P. variegata.
*P. violacea.
Actinococcus subcutaneus.
Ahnfeldtia plicata.
*Chondrus crispus.
*Phyllophora Brodiæi.
P. Brodiæi var. catenata (o).
*P. membranifolia.
Sterrocolax decipiens (o).
*Agardhiella tenera.
Cystoclonium purpurascens.
C. purpurascens var. cirrhosum (o).
*Champia parvula.
*Lomentaria uncinata.
Rhodymenia palmata (o).
*Grinnellia americana.
Gloiosiphonia capillaris (o).
Polyides rotundus.
Corallina officinalis.
Hildenbrandia prototypus.
Melobesia farinosa.
M. membranacea (o).
M. pustulata.

The warm-water sublittoral formation of the summer is known not only from the dredgings in the deeper waters, but also from many observations in the shallow waters at a number of points at or near Woods Hole, where the algal flora along shore has been studied by the writer for some ten summers. Extensive studies along shore have not been possible in the regions of the cool-water sublittoral formation (that is, in the lower portion of Buzzards Bay and westerly portion of Vineyard Sound), and the flora of the shallow water is known only at a few points, such as Gay Head, portions of Cuttyhunk, and Penikese.

It is interesting to note that a considerable number of species in the above lists are restricted wholly or largely to shallow water in a zone from low-water mark to a depth of 3 to 6 feet. The characteristic algæ in this zone of the upper warm-water sublittoral are:

Chætomorpha linum.
Cladophora, the species in the above lists.
Ectocarpus, the species in the above lists.
Pylaiella littoralis.
Sphacelaria cirrhosum.
S. radicans.
Punctaria plantiginea.
Castagnea virescens.
Chordaria flagelliformis.
Leathesia difformis.
Mesogloia divaricata.
Ralfsia clavata.
Chorda filum.
Callithamnion Baileyi.
C. Baileyi var. laxum.
Ceramium rubrum.
Chondria dasyphylla.
C. sedifolia.
C. tenuissima.
C. tenuissima var. Baileyana.
Polysiphonia fastigiata.
P. fibrillosa.
P. variegata.
P. violacea.
Chondrus crispus.
Champia parvula.
Lomentaria uncinata.
Grinnellia americana (on piles).
Melobesia farinosa.
M. pustulata.

The algæ listed in the *Zostera* formation (c) may also properly be included in this, the upper warm-water sublittoral formation.

The summer temperature of the water is undoubtedly the chief factor in determining the warm-water sublittoral formation as a whole. The degree of exposure to wave action or tide currents and the character of the attachment are of course important factors affecting the local distribution of the algæ along the shores. Thus, the vegetation off exposed points, as at Nobska or on the ledges in the passage of Woods Hole, is subjected to conditions very different from those of neighboring sheltered coves. As stated before, the summer temperature in Great Harbor, Woods Hole (as shown by daily averages

covering the years 1902–1906), passes 60° F. about June 1, holds between 69° and 71° from about July 11 to August 28, and passes 60° in its autumn decline about October 12. The bottom temperatures were taken at a large number of stations in both the Bay and the Sound during the month of August. They were at this time highest in the upper portion of Buzzards Bay, where 71.3° was recorded, while in Vineyard Sound 68.8° was recorded off Falmouth, and 66.9° off the west end of the Middle Ground, these temperatures becoming in general lower toward the mouth of Buzzards Bay and the westerly portion of Vineyard Sound. The warm-water sublittoral formation may, then, be said to endure a temperature of about 70° for midsummer, and its most favorable temperature is perhaps close to 60° or above, although many species live in colder water. It would be very interesting to know to what degree the place of the warm-water sublittoral is taken by representatives of the cool-water sublittoral as the temperature of the water falls during the autumn. The cool-water sublittoral might be expected to invade the narrow and easterly portion of Vineyard Sound and the upper portion of Buzzards Bay, but we have no data on this problem.

THE ZOSTERA FORMATION.

There are a number of algæ which have the habit of growing frequently or invariably attached to *Zostera.* They, together with the eel grass itself, constitute a very clearly defined assemblage which is here called the *Zostera* formation. It is really a specialized region of the warm-water sublittoral formation, for the eel grass vegetates during the summer when the water is warm. Many of the species listed below will consequently be found in the lists of the latter formation (B).

Zostera marina, the eel grass, is very abundant in all sheltered regions of both Bay and Sound, forming thick beds in shallow waters. It was frequently found at inshore stations of the survey, and also at scattered stations in deeper waters of the Bay and Sound (chart 266), being dredged in 2 to 13 fathoms, over sandy, stony, and muddy bottoms. The eel grass, however, prefers shallow water in coves and bays or along sheltered coasts, where it grows luxuriantly, developing extensive beds in depths of 2 feet to 2 fathoms or more. Under these conditions the formation described below is frequently developed to a greater or less extent. Species preceded by the asterisk are the most important forms; those which are rare or occasional are designated by (O).

When the *Zostera* grows in very quiet and shallow waters the blue-green alga, *Anabæna torulosa,* is common on the mud at the base of the plants, frequently breaking loose and floating on the surface as slimy masses. *Lyngbya majuscula* sometimes forms extensive tufted growths and, breaking free, also floats on the surface. Other blue-green algæ in the *Lyngbya* salt-marsh association (I) may be present. *Hydrocoleum glutinosum* and *Glœocystis zostericola* form coatings on the leaves, and *Enteromorpha clathrata, E. plumosa,* with other species, and sometimes species of *Cladophora,* grow in loosely attached masses. These algæ are all forms which may be expected in brackish water.

When the eel grass grows in more open or exposed situations the list of epiphytes includes species which are never found in brackish water. Among these the following are conspicuous:

*Cladophora gracilis and occasionally other species.
Ascocyclus orbicularis (o).
*Ectocarpus confervoides.
E. penicillatus.
*E. siliculosus.
Sphacelaria cirrhosa (o).
*Desmotrichum balticum (in the spring).
*D. undulatum (in the spring),
Pogotrichum filiforme (o).
*Punctaria latifolia.
Rhadinocladia Farlowii (o).
Giraudia sphacelarioides (o).
Castagnea virescens (o).
*C. Zosteræ.
Hecatonema maculans (o).
Myrionema vulgare.
Stilophora rhizodes (o).
Erythrotrichia ceramicola.
*Porphyra leucosticta (in the spring).
Chantransia secundata.
*C. virgatula.
Antithamnion cruciatum (in deep water).
Callithamnion Baileyi.
C. Baileyi var. laxum.
*C. byssoideum.
*C. corymbosum.
*C. roseum.
*Ceramium fastigiatum.
C. rubrum.
*C. strictum.
*C. tenuissimum.
*Seirospora Griffithsiana.
*Spyridia filamentosa (o).
Chondria dasyphylla (o).
Chondria sedifolia (o).
*Dasya elegans.
*Polysiphonia Harveyi.
*P. Olneyi.
P. variegata (o).
Rhododermis Georgii (o).
Melobesia farinosa.
*M. Lejolisii.

The *Zostera* formation endures temperatures considerably higher than those given for the range of the warm-water sublittoral, especially where the eel grass grows in coves or other sheltered stations. Such waters may remain above 70° F. for many days, probably at times reaching as high as 75° to 78°. These conditions as to heat are the most extreme of any in this region, except of course the small brackish pools and ditches of the salt marshes.

A WINTER SUBLITTORAL FORMATION.

It is clear that, as the temperature of the Bay and Sound falls during the autumn, the conditions become less favorable for the warm-water sublittoral flora. Many species characteristic of waters south of Cape Cod pass out of season, although certain species which may be said to endure the summer's heat are at their best in the winter season. A cold-water winter sublittoral formation is thus developed, which extends throughout the Bay and Sound, reaching its best development probably in the late winter and early spring.

We know nothing of this winter and spring flora in the deeper waters of the Bay and Sound, for there have been no dredgings for algæ at these seasons. The cool-water sublittoral formation of the lower portion of the Bay and westerly portion of the Sound would be expected to enter the more sheltered regions occupied by the warm-water sublittoral during the summer, but how far it may extend is a matter of conjecture. Undoubtedly species appear which are not present in either Bay or Sound during the summer, some probably developing from resting spores that carry the forms through the summer, and others coming in by means of spores brought from a distance.

It is probable that numbers of northern species, the spores of which might be brought from a distance, would be able to establish themselves, develop to maturity, and perhaps pass through several generations before the temperature rises sufficiently in the spring to put an end to their growth. Species of *Cladophora*, *Ectocarpus*, and other rapidly growing green and brown algæ, reproducing by zoospores, are admirably fitted for a periodical winter invasion, and some of the smaller red algæ which mature quickly would also be expected to take part in such a migration.

Some observations on the algal vegetation along shore in shallow water have been made during the winter and spring, and if these are indices of the general change through-

out the sublittoral, the flora of the bottom of the Bay and Sound must be very different indeed from that of the summer. Especially interesting are the series of studies of the flora of Spindle Rocks, Woods Hole, which were made at intervals throughout a 12-month cycle in 1904 and 1905. These are described in the next section of this paper. Such intensive studies over long periods of time are very much to be desired to determine the seasonal changes in algal floras.

We give below a list of the algæ so far known to be present in the cold-water sublittoral formation of the winter and spring:

Monostroma Grevillei.
Ulva Lactuca.
Chætomorpha Linum.
Cladophora arcta.
C. lanosa.
C. lanosa var. uncialis.
Derbesia vaucheriæformis.
Ectocarpus æcidioides.
E. confervoides.
E. elegans.
E. fasciculatus.
E. granulosus.
E. ovatus.
E. penicillatus.
E. siliculosus.
E. tomentosus.
Pylaiella littoralis.
Sorocarpus uvæformis.
Asperococcus echinatus.
Desmotrichum balticum.
D. undulatum.
Pogotrichum filiforme.
Punctaria latifolia.
P. plantaginea.
Desmarestia viridis.
Dictyosiphon fœniculaceus.
Giraudia sphacelarioides.
Castagnea virescens.
Chordaria flagelliformis.
Hecatonema maculans.
Myrionema corunnæ.
M. vulgare.
Chorda tomentosa.
Laminaria Agardhii.
Haplospora globosa.
Scaphospora Kingii.
Erythrotrichia ceramicola.
Porphyra laciniata.
P. leucosticta.
Chantransia secundata.
C. virgatula.
Antithamnion americanum.
Callithamnion Baileyi.
Ceramium rubrum.
Polysiphonia fastigiata.
P. nigrescens.
P. urceolata.
Rhodomela Rochei.
R. subfusca.
Ahnfeldtia plicata.
Chondrus crispus.
Sterrocolax decipiens.
Rhodymenia palmata.
Gloiosiphonia capillaris.
Rhododermis Georgii.

The cold-water sublittoral formation accepts a winter temperature, which for at least two and a half months probably averages under 35° F., as indicated by the records for Great Harbor, Woods Hole (the average temperature between December 25 and March 15 for the years 1902–1906 was below 35°). Many of the species of this formation reach their best vegetative condition and fruit during the spring, and then pass out of season. During this period the temperature of the water rises steadily, passing 60° about June 1.

THE LITTORAL FORMATIONS.

As has been stated before, the algal growths in the littoral region are not very striking in the immediate vicinity of Woods Hole, chiefly for these reasons, (1) that the tides are small, (2) that the shore line is very broken, (3) a marked boreal flora is absent, and (4) the scraping of floating ice in the winter prevents the development of an extensive littoral flora at this season. Neighboring coasts exposed sufficiently as to be free from floating ice, as at Cuttyhunk, have heavy growths of algæ in the winter, but there have been no opportunities for thorough studies at this season. These growths are, however, undoubtedly composed largely of rockweeds (*Fucus* and *Ascophyllum*).

The littoral formations of the different seasons at Woods Hole are of a very spotted character, rarely being so extensive as to attract attention and generally breaking up at once into small associations. Of these the following are at times very evident: The *Calothrix* associations (3), the *Rivularia* associations (4), the *Pleurocapsa* association

(5), the *Ulva*, *Enteromorpha*, and *Monostroma* associations (6), the *Ulothrix* associations (7), the *Phyllitis* and *Scytosiphon* associations (15), the *Fucus* and *Ascophyllum* associations (25), the *Bangia* association (27), the *Porphyra* association (28), the *Nemalion* association (30).

THE PLANKTON.

The only studies on the plant life present in the plankton of the region covered by the survey have been those of Peck (1894 and 1896), chiefly in relation to its value as a source of food, especially for the menhaden. In his second paper Peck (1896, p. 356) records his observations on the plankton of Buzzards Bay, describing and figuring a number of microorganisms belonging to the Peridinales and Bacillariales (Diatomales), together with animal forms. His studies were quantitative rather than qualitative, and the identification of his material as regards plant life was only partial, but it is clear that the plankton of these regions is very abundant and widespread, as would be expected of warm, shallow bodies of water.

Chapter IV.—A REPORT ON THE ALGÆ OF SPINDLE ROCKS, WOODS HOLE HARBOR.

That many algæ have well-defined seasons of vegetative growth is well known, but there have been very few detailed or intensive studies of particular regions covering sufficiently long periods to give important conclusions. It is certain, however, that there are seasonal floras which follow one another over the same area in much the same manner as terrestrial floras. This study was undertaken in the hope that observations on a particular group of rocks at Woods Hole at various seasons might bring out some important facts on the life habits of the algæ of this region.

The rocks selected for the study seemed particularly well adapted for the purpose. They were a group of bowlders called by the writer Spindle Rocks because, lying off Grassy Ledge at the entrance to the ship channel in the passage of Woods Hole, they bore a light on an iron spindle. Unfortunately for the continuation of the work, the rocks were removed during the summer of 1906 by dredging operations of the Government to widen the ship channel, and the spindle was shifted to another position.

The destruction of the old group of rocks of course ended the observations, which had been in progress for 15 months, beginning in the summer of 1904 and extending through the summer of 1905. The studies over this period, however, are of considerable interest, since they cover the seasonal changes of one entire year. They are illustrated by 8 charts, which are selected from a series of 10 made during this period.

Spindle Rocks, as shown on the charts (267–274), was a group of 10 bowlders, the smallest having a length of about 5 feet and the largest of about 9½ feet. Some portion of each rock was exposed at low water and all of the rocks were covered at high tide. The rocks lay to the north or right of the entrance to the ship channel leading through the passage from Woods Hole Harbor to Buzzards Bay and were an outlying portion of Grassy Ledge. The rocks were exposed to very swift tide currents, which flow through the channel at a rate of 5 to 8 miles an hour. The ledge fell off abruptly on all sides, but between the rocks the depth was 1 to 6 feet. The outlines of the bowlders were plotted in a chart showing their form and position as viewed from above. The low-water mark was sketched for each rock by a dotted line, and above it two other lines indicating tide marks 2 and 5 inches, respectively, above low water. A plate was made from the original drawing and charts were printed to be used for making the records. In the work of preparing this chart the writer received much assistance from Mr. F. W. Cushwa.

The study was concerned entirely with the flora over the tops of the rocks and below low-water mark to a depth of 3 to 6 feet. Each species was given a number, and charts were plotted at intervals, the numbers with accompanying notes showing the position and abundance of the algæ over the rocks. It was found most convenient in practice for two persons to take the record of the ledge, one making the examination and the other recording by number on the printed chart the position of each species. At the end of the study the list of species was arranged in the order adopted in the Catalogue,

necessitating a new set of numbers, which were substituted for the old. In all, 50 species were recorded on the rocks during the 15 months' study, the list being as follows:

List of algæ found on Spindle Rocks.

CYANOPHYCEÆ.

1. Calothrix scopulorum.
2. Rivularia atra.

CHLOROPHYCEÆ.

3. Ulothrix implexa.
4. Ulva Lactuca.
5. Ulva Lactuca var. rigida.
6. Enteromorpha crinita.
7. Enteromorpha intestinalis.
8. Enteromorpha prolifera.
9. Cladophora gracilis.
10. Cladophora lanosa.
11. Chadophora lanosa var. uncialis.
12. Codiolum gregarium.

PHÆOPHYCEÆ.

13. Ectocarpus æcidioides.
14. Ectocarpus confervoides.
15. Ectocarpus fasciculatus.
16. Ectocarpus granulosus.
17. Ectocarpus ovatus.
18. Ectocarpus penicillatus.
19. Ectocarpus siliculosus.
20. Ectocarpus tomentosus.
21. Sorocarpus uvæformis.
22. Desmotrichum balticum.
23. Desmotrichum undulatum.
24. Phyllitis fascia.
25. Punctaria plantaginea.
26. Scytosiphon lomentarius.
27. Desmarestia viridis.
28. Chordaria flagelliformis.
29. Mesogloia divaricata.
30. Myrionema corunnæ.
31. Chorda filum.
32. Chorda tomentosa.
33. Laminaria Agardhii.
34. Laminaria Agardhii var. vittata.
35. Fucus vesiculosus.
36. Sargassum Filipendula.

RHODOPHYCEÆ.

37. Porphyra laciniata.
38. Acrochætium secundatum.
39. Acrochætium virgatulum.
40. Nemalion multifidum.
41. Callithamnion Baileyi.
42. Callithamnion corymbosum.
43. Ceramium rubrum.
44. Chondria dasyphylla.
45. Dasya elegans.
46. Polysiphonia fibrillosa.
47. Polysiphonia urceolata.
48. Polysiphonia violacea.
49. Chondrus crispus.
50. Champia parvula.

The detailed records of the accompanying eight charts (no. 267–274) have been given in the legends, and it is only necessary in this account to present the most important conclusions from the study of the rocks throughout the seasons.

During the winter the tops of the rocks were scraped perfectly bare of vegetation, and even of barnacles, by the floating ice carried back and forth through the channel by the swft tides.[a] The conditions at the end of the winter of 1905 are shown in chart 267, recorded March 17, 1905. It is interesting to compare this chart with chart 274, of December 30, 1904, which shows algæ well distributed over the upper portion of almost every rock. That vegetation had been entirely swept away in the two and one-half months elapsing between the two records, and no algæ had as yet formed a perceptible new growth. This history is probably that of every bowlder along the shore

[a] There are, however, winters at Woods Hole when practically no floating ice is present, and at such times the algæ are not affected.

when exposed to similar ice scraping and shows clearly why the littoral flora in mid-winter is so little developed in this region. Returning to chart 267, it will be seen that the algæ were all below low-water mark, the most conspicuous forms being *Ceramium rubrum* (43) and *Chondrus crispus* (49), forming a zone around the rocks.

The group of rocks a month later presented a very different aspect, as shown in chart 268, recorded on April 22. *Cladophora lanosa* var. *uncialis* (11) had appeared in considerable quantity near low-water mark, and somewhat lower down was an imperfect zone consisting of young growth of *Phyllitis fascia* (24) and *Scytosiphon lomentarius* (26). *Polysiphonia urceolata* (47) had appeared well below low-water mark and was the most conspicuous member of a zone of red algæ, including *Ceramium rubrum* (43) and *Chondrus crispus* (49). There were present *Sorocarpus uvæformis*, four species of *Ectocarpus*, and the two species of *Desmotrichum*, all new to the rocks, showing how quickly such algæ, reproducing by zoospores, may establish themselves. A notably new form was *Chorda tomentosa* (32), which had begun to appear.

Chart 269, recorded May 22, shows the conditions after another month, and when the spring flora was at its full development. *Cladophora lanosa* var. *uncialis* (11) was still the dominant green alga, but *Enteromorpha intestinalis* (7) had begun to appear, and these two algæ had extended the green zone much higher on the rocks than at the previous date, April 22 (chart 268). The brown zone at low-water mark, composed chiefly of *Ectocarpus penicillatus* (18), *Phyllitis fascia* (24), *Scytosiphon lomentarius* (26), and *Chordaria flagelliformis* (28), was much more evident. *Polysiphonia urceolata* (47) was very conspicuous in the zone of red algæ below the brown. *Chorda tomentosa* (32) was abundant.

Conditions were very greatly changed after another month, as shown in chart 270, recorded June 29, the spring flora having given place to the beginning of the summer flora. *Cladophora lanosa* var. *uncialis* had entirely disappeared, and the prominent green zone above low-water mark was composed of *Ulothrix implexa* (3) and *Enteromorpha intestinalis* (7), with young growths of *Ulva Lactuca* var. *rigida* (5). The brown zone near low-water mark was now chiefly *Scytosiphon lomentarius* (26) and *Chordaria flagelliformis* (28); *Phyllitis fascia* was represented by only a few old plants and *Ectocarpus penicillatus* had disappeared. The other species of *Ectocarpus*, *Desmotrichum*, and *Sorocarpus uvæformis*, as well as *Chorda tomentosa*, were also no longer present. *Polysiphonia urceolata* had disappeared, its place being taken by *Polysiphonia violacea* (48), which with *Ceramium rubrum* (43) and *Chondrus crispus* (49) chiefly composed the zone of red algæ below the brown zone. *Nemalion multifidum* (40), a characteristic summer species, had begun to appear at and above low-water mark.

The typical summer flora is shown on chart 271, recorded July 22. The conspicuous green alga was *Ulva Lactuca* var. *rigida* (5), growing in large patches with other green algæ in small quantities. There was a well-defined brown zone just above low water composed chiefly of *Chordaria flagelliformis* (28) and *Scytosiphon lomentarius* (26), both bearing *Ectocarpus confervoides* (14) as a conspicuous epiphyte; *Phyllitis fascia* had disappeared. *Nemalion multifidum* (40) was now plentiful, fringing the rocks at low-water mark. Below the brown zone and mixed with it were abundant growths of *Ceramium rubrum* (43), *Polysiphonia violacea* (48), and *Chondrus crispus* (49). Chart 272, recorded September 2, is similar to chart 271, but with certain features more pronounced. The most

prominent zone (much more conspicuous than in chart 271) was just below low water and composed of *Ceramium rubrum* (43) and *Polysiphonia violacea* (48), these two forms having taken the region formerly occupied by the brown zone. Chart 273, recorded September 19, 1904, a year previous to the last, is interesting because there was no *Chordaria flagelliformis* that season and very little *Polysiphonia violacea*, but an abundance of *Polysiphonia fibrillosa* (46), which took the place of the first two species, forming with *Ceramium rubrum* (43) a dense zone below low-water mark.

The conditions at the beginning of the winter and before the rocks were scraped by floating ice are shown in chart 274, recorded December 30, 1904. This chart in the sequence follows chart 273, of September 19, 1904, and precedes chart 267, of March 17, 1905, by two and one-half months. The prevailing green alga was *Cladophora lanosa* var. *uncialis* (11), which had taken the place of *Ulva Lactuca* var. *rigida* (5), so abundant in the summer, but now only represented by the bases of old plants. The brown zone was composed of *Phyllitis fascia* (24) and *Scytosiphon lomentarius* (26); there was no *Chordaria flagelliformis*. *Ceramium rubrum* (43) was abundant below the brown zone but *Polysiphonia fibrillosa* (46) had almost disappeared. Two species of *Ectocarpus* were present, together with several other epiphytic brown and red algæ.

A close study of this series of charts will show very graphically the general nature and extent of the seasonal changes that must take place on very many ledges and groups of rocks along the coast, and similar seasonal changes would be expected wherever there is a well-developed littoral and sublittoral flora near low-water mark. Intensive studies of this character of well-chosen situations are far more important for our knowledge of seasonal habits and algal successions than random collecting undertaken along the shore. It is much to be desired that such work be systematically undertaken by those in a position to make detailed records over extended periods. Perhaps this brief record of a study (abruptly terminated by the destruction of the selected station), which shows such interesting results, will lead others to make similar investigations.

In conclusion we wish to acknowledge our indebtedness to Miss Lillian J. MacRae, who, with the assistance of Mr. Collins, made the records of several charts at seasons when it was impossible for us to be at Woods Hole.

Chapter V.—THE DISTRIBUTION OF THE MARINE ALGÆ IN THE DEEPER WATERS OF BUZZARDS BAY AND VINEYARD SOUND.

By the deeper waters of Buzzards Bay and Vineyard Sound are meant the depths of 2 fathoms or more, thus excluding the coast line between tide marks and the shallows just below. The reader is referred to the "Description of dredging stations occupied during present Survey," section 1, page 201, of this report, for detailed information as to the position of the stations, dates of the dredgings, depths, etc., which it is unnecessary to specify in this general account.

The varied character of the bottom of Buzzards Bay and Vineyard Sound is responsible for many peculiarities of the algal vegetation. There are reefs of large bowlders off certain exposed points, but frequently the bottom in such situations is composed chiefly of rounded pebbles of various sizes. Then there are regions of gravel often mixed with shells and shell fragments, and large tracts of sand which are veritable deserts as far as plant life is concerned. Finally, there are some very extensive regions of black mud, especially characteristic of the upper portions of Buzzards Bay; these are likewise very barren of plant life, except where beds of *Zostera marina* are present in relatively shallow water. These characteristics are fully described in section 1, chapter II, pages 29–33, and are graphically shown on chart 227.

The lists of species are arranged after the plan in Collins' "Preliminary Lists of New England Plants: V. Marine Algæ," Rhodora, volume II, page 41, 1900. That is, they are grouped alphabetically in the order of the Chlorophyceæ, Phæophyceæ, and Rhodophyceæ. By far the greater number of species in the deeper waters belong to the Rhodophyceæ, the Phæophyceæ coming next in number, and the Chlorophyceæ claiming only a small proportion.

The dredgings of the survey fall into two groups, (1) those in the middle regions of the Bay and Sound, at some stations within one-fourth of a mile from the shore, but generally in water of 5 fathoms or more in depth, and (2) those "inshore," i. e., immediately skirting the coast line in water sometimes as shallow as 2 fathoms. The material in this account will for geographical reasons be grouped under the following headings:

1. The middle regions of Buzzards Bay.
2. The middle regions of Vineyard Sound.
3. Certain inshore regions of particular interest.
4. Some statistics relative to the distribution of algæ in Buzzards Bay and Vineyard Sound.

1. THE MIDDLE REGIONS OF BUZZARDS BAY.

Buzzards Bay, for convenience in this account, has been divided into an upper and lower portion by a line running from the west end of Naushon (Robinsons Hole) to Round Hill Point.

The upper portion of Buzzards Bay in the middle regions has a very scanty algal flora. This is easily accounted for by the character of the bottom, which for the most

part consists of mud or fine muddy sand. Mud and fine sand furnish poor attachment for algæ, and their shifting nature, especially when disturbed by storms and tide currents, give conditions very unfavorable for algal growth. The water is relatively shallow in this region, occasionally more than 7 fathoms deep, but generally under 6 fathoms. The following species were found growing in the upper portion of the Bay, the numbers referring to *Fish Hawk* stations:

Arthrocladia villosa, 7653, few.
Chordaria flagelliformis, 7653 and 7654, few.
Desmarestia aculeata, 7653 and 7655, few.
Desmarestia viridis, 7653 many; 7654, few.
Laminaria Agardhii, 7653 and 7654, few.
Ralfsia clavata, 7639, few.
Sargassum Filipendula, 7630 (1907), 7639, and 7654, few.
Agardhiella tenera, 7615, 7632, 7645, 7648, 7649, and 7650, few.
Callithamnion Baileyi, 7653, few.
Ceramium tenuissimum, 7652, few.
Champia parvula, 7610 (1907), 7653 and 7654, many; 7630 (1907), 7648 and 7651 (1907), few.
Cystoclonium purpurascens, 7653 and 7654, few.
Cystoclonium purpurascens var. cirrhosum, 7639 and 7653, few.
Dasya elegans, 7632, few.
Griffithsia tenuis, 7632, few.
Grinnellia americana, 7621, 7628, 7629 and 7648, many; 7615, 7624, 7625, 7630, 7632, 7634, 7635, 7639, 7649 and 7653, few.
Lithothamnion polymorphum, 7621, few.
Lomentaria uncinata, 7632 and 7653, few.
Phyllophora Brodiæi, 7610, 7611, 7613, 7614, 7615, 7617, 7618, 7627 and 7654, few.
Phyllophora membranifolia, 7635, many; 7610 (1907), 7621 (1907), 7630, 7630 (1907), 7631, 7632, and 7639 (1907), few.
Polysiphonia nigrescens, 7648, 7654, and 7655, many; 7610, 7615, 7636, 7637, 7638, 7639, 7649, and 7650, few.
Polysiphonia variegata, 7632, few.
Rhodomela subfusca, 7639 and 7652, few.
Rhodymenia palmata, 7653 and 7656, few.

The lower portion of Buzzards Bay presents conditions more varied than the upper portion. The depth is generally over 8 fathoms, and all of the stations of the greatest depth in the Bay (10 to 19 fathoms) are found in this region. The nature of the bottom changes near the entrance of the Bay from mud and sand, characteristic of the upper portion, to gravel and stones, present at a number of stations (7664, 7665, 7666, 7667, 7670, 7671, 7672, 7673). This is a much more favorable bottom for algæ, and the number of species and total quantity of vegetation are very much greater than in the upper portion of the Bay. The following species were found in the lower portion of the Bay:

Chorda filum, 7656, few.
Chordaria flagelliformis, 7656, many; 7667, few.
Desmarestia aculeata, 7656, 7657, 7662, and 7671, few.
Desmarestia viridis, 7665, few.
Dictyosiphon hippuroides, 7656, many.
Ectocarpus fasiculatus, 7656, many.
Laminaria Agardhii, 7656 and 7657, many; 7660, 7662, and 7663, few.
Laminaria Agardhii var. vittata, 7670, many; 7664, 7665, 7666, 7667, and 7671, few.
Ralfsia clavata, 7671, few.
Sargassum Filipendula, 7657, few.
Agardhiella tenera, 7661, few.
Ahnfeldtia plicata, 7656, few.
Antithamnion cruciatum, 7671, few.
Callithamnion Baileyi, 7656, many.
Ceramium rubrum, 7656, many; 7665 and 7670, few.
Champia parvula, 7661, 7662, and 7663, many; 7656, 7657, 7664, 7668, 7670, 7671, and 7672, few.
Chondrus crispus, 7656 and 7659, many; 7663, 7665, 7668, 7670, 7672, and 7673, few.
Corallina officinalis, 7663, many.
Cystoclonium purpurascens, 7656, 7659, and 7660, few.
Cystoclonium purpurascens var. cirrhosum, 7651 (1907), 7656, 7659, 7662 (1907), 7664, 7666, 7672, and 7673, few.
Dasya elegans, 7656, 7666, 7674, and 7675, few.
Delesseria sinuosa, 7664, few.
Grinnellia americana, 7671, many; 7660, 7661, 7663, 7670, and 7675, few.
Lithothamnion polymorphum, 7659, few.
Lomentaria uncinata, 7671 and 7675, few.
Melobesia membranacea, 7672, many.

Phyllophora Brodiæi, 7656, many; 7663, 7672 and 7673, few.

Phyllophora membranifolia, 7659 and 7662, many; 7657, 7660, 7663 (1907), 7664, 7666, 7672 (1907), and 7675, few.

Pleonosporium Borreri, 7675, few.

Polyides rotundus, 7659, many; 7660 and 7666, few.

Polysiphonia elongata, 7656, 7662 (1907), 7665, and 7675, few.

Polysiphonia nigrescens, 7659, many; 7656, 7664, 7666, 7668, and 7672, few.

Polysiphonia urceolata, 7670, 7673, and 7675, few.

Polysiphonia violacea, 7664, few.

Rhodomela subfusca, 7656 and 7667, few.

Rhodymenia palmata, 7664, 7665, 7666, 7667, 7670, and 7671, few.

Seirospora Griffithsiana, 7660, few.

Spyridia filamentosa, 7671, many; 7656 and 7675, few.

Summarizing this statement of the algal vegetation in Buzzards Bay, it may be said that the life conditions are much more favorable in the lower portions of the Bay than in the upper, since the bottom is generally stony and the water clearer, because silt and mud are less frequent. These characteristics are graphically shown on chart 227, and it will be noted that the greater part of Buzzards Bay has a muddy bottom. Such regions in the deeper waters are almost deserts as regards vegetation. The algal flora of the upper portion of Buzzards Bay is, in the summer, composed of species characteristic of the warm-water sublittoral formation, which also extends somewhat into the lower portions of the Bay. However, the vegetation changes markedly toward the entrance of the Bay, both as to its characteristics and its quantity, as is shown by the above lists. Species appear which are peculiar to the cool-water sublittoral formation. Around the exposed reefs of Sow and Pigs the vegetation is typical of this formation, which is presented in even greater luxuriance off Gay Head.

2. THE MIDDLE REGIONS OF VINEYARD SOUND.

The conditions in Vineyard Sound differ from those of Buzzards Bay in several respects. The tides which flow east with the flood and west with the ebb have a velocity of 1 to 3 knots an hour, which is so strong a current that extensive deposits of mud or fine silt are generally rendered impossible. The bottom is in consequence chiefly hard sand, frequently mixed with shell fragments, gravel, or stones. There is little or no mud in the middle regions of the Sound. The average depth is somewhat greater than that of the Bay, but not enough to be an important factor in determining the character of the vegetation. There are no large areas of shallows under 6 fathoms, as are found in the upper portion of Buzzards Bay, the Middle Ground being the only extensive region of shoal water, and that is composed chiefly of sand and is quite barren of vegetation.

Vineyard Sound within the limits of this Survey (that is, from a line drawn between the westerly end of Cuttyhunk and Gay Head to a line between Falmouth Heights and East Chop) has for convenience been divided into three regions as follows: (*a*) The westerly portion from the entrance to a line between the west end of Naushon (Robinsons Hole) and Kopeecon Point (Cape Higgon), (*b*) the narrow portion of the Sound between Naushon and Marthas Vineyard to a line connecting Nobska Point and West Chop, and (*c*) the easterly portion of the Sound from the last line to one between Falmouth Heights and East Chop.

The westerly portion of Vineyard Sound includes large areas with a bottom of hard sand or sand with shell fragments, but exceptions to these conditions were found at a

number of stations (see chart 227). The greatest depths were between 17 and 19 fathoms (chart 227), and the average for this portion of the Sound was about 12⅓ fathoms. The following is the list of algæ found in the deeper waters of the westerly portion of Vineyard Sound:

Arthrocladia villosa, 7734, many; 7725, 7728 and 7729, few.
Chorda filum, 7567, 7571, and 7591, few.
Cladostephus verticillatus, 7717, many; 7598 and 7734, few.
Desmarestia aculeata, 7718, many; 7566, 7588, 7595, 7596, 7719, 7720, and 7730, few.
Desmarestia viridis, 7731 (1907), many; 7677, 7678, 7706, 7707, 7710, 7725, 7728, 7730, and 7734, few.
Dictyosiphon hippuroides, 7725, many; 7676, 7729, and 7730, few.
Ectocarpus siliculosus, 7717 and 7728, few.
Laminaria Agardhii, 7718, many; 7581 (1907), 7582 7583, 7584, 7588, 7589, 7592, 7593, 7595, 7599, 7677, 7702, 7703, 7706, 7719, and 7728, few.
Laminaria Agardhii var. vittata, 7582, 7583, 7679, 7680, 7681, 7701, 7704, 7706, 7707, 7719, 7720, 7723, 7724, and 7731, few.
Laminaria digitata, 7593 and 7722, few.
Actinococcus subcutaneus, 7583 and 7595, few.
Agardhiella tenera, 7735, many; 7728, 7730, and 7734, few.
Ahnfeldtia plicata, 7593, 7598, 7599, 7718, 7719, 7720, 7721, 7724, and 7725, few.
Antithamnion cruciatum, 7724 and 7735, many; 7566, 7571, 7690, 7720, 7730, and 7734, few.
Antithamnion plumula, 7678, few.
Callithamnion roseum, 7725, few.
Ceramium rubrum, 7721, many; 7571, 7575, 7576, 7589, 7593, 7676, 7680, 7701, 7704, 7710, 7717, 7719, 7722, 7731 (1907), and 7734, few.
Ceramium tenuissimum, 7724, 7725, and 7726, many; 7730, few.
Champia parvula, 7572 and 7724, many; 7566, 7567, 7568, 7569, 7571, 7574, 7575, 7576, 7578, 7588, 7676, 7703, 7725, 7728, 7729, and 7734, few.
Chondrus crispus, 7718 and 7720, many; 7566, 7581 (1907), 7582, 7583, 7584, 7585, 7589, 7591, 7596, and 7731 (1907), few.
Corallina officinalis, 7566, 7583, and 7596, few.
Cystoclonium purpurascens, 7720 and 7729, few.
Cystoclonium purpurascens var. cirrhosum, 7707, 7730, and 7731 (1907), many; 7585, 7601, 7676, 7678, 7686, 7692, 7693, 7703, 7706, 7717, 7718, 7719, and 7722, few.
Dasya elegans, 7734, few.
Delesseria sinuosa, 7701, 7719, and 7720, many; 7582, 7591, 7593, 7595, 7690, 7692, 7693, 7703, 7709, and 7721, few.
Grinnellia americana, 7734 and 7735, many; 7575, 7576, 7589, 7724, 7725, 7727, 7729, 7730, and 7736, few.
Lomentaria rosea, 7593, 7708, and 7709, few.
Lomentaria uncinata, 7734 and 7735, few.
Melobesia pustulata, 7582, many.
Phyllophora Brodiæi, 7583, 7584, 7591, 7595, 7596, and 7598, few.
Phyllophora membranifolia, 7706, 7710, 7719, 7722, 7725, and 7729, few.
Plumaria elegans, 7720, many; 7584, 7719, and 7728, few.
Polyides rotundus, 7581 (1907), 7701, and 7717, few.
Polysiphonia elongata, 7685, 7701, 7723, and 7726, many; 7581 (1907), 7678, 7686, 7698, 7702, 7706, 7709, 7717, 7724, 7725, 7727, 7728, 7730, 7731 (1907), and 7734, few.
Polysiphonia nigrescens, 7724, 7725, 7728, 7729, 7730, 7731 (1907), and 7734, many; 7581 (1907), 7717, 7718, and 7726, few.
Polysiphonia violacea, 7681, 7704, and 7721, few.
Rhodomela Rochei, 7731 (1907), few.
Rhodymenia palmata, 7567, 7569, 7578, 7582, 7584, 7585, 7588, 7591, 7593, 7595, 7701, 7703, 7708, 7718, 7719, 7720, 7723, 7724, 7728, 7729, and 7731 (1907), few.
Seirospora Griffithsiana, 7728, many; 7729, few.
Spermothamnion Turneri, 7585, 7588, 7589, 7598, 7717, and 7719, few.
Spyridia filamentosa, 7724, 7725, 7726, and 7735, many; 7571, 7572, 7588, and 7720, few.

It is an interesting fact that the growths of algæ are most luxuriant nearest Gay Head, the Cuttyhunk side of Vineyard Sound in the deeper waters being very barren of vegetation. The depth is nowhere sufficiently great to be an important factor in determining the distribution of the algæ, for stations 7719 (17 fathoms), 7582, 7583, and 7584 (all about 15 fathoms) gave a large variety of species in considerable quantity. Gravelly and rocky bottoms generally have the greatest quantity of vegetation. The dredgings determined the presence of extensive areas of sand, which support little or

no algal life. The most important of these were around the following groups of stations: (7677, 7592); (7708, 7709, 7590); (7679, 7681, 7702); (7577, 7597, 7682, 7698, 7699, 7700, 7727); (7573, 7574, 7695); (7569, 7570, 7736).

Proceeding eastward into the Sound from the entrance the most marked change in the algal life is the appearance of such species as *Arthrocladia villosa, Chorda filum, Dictyosiphon hippuroides, Agardhiella tenera, Ceramium tenuissimum, Champia parvula,* and *Grinnellia americana.* These were not found in the deeper waters at the entrance of the Sound, but were all fairly abundant eastward, *Agardhiella, Champia,* and *Grinnellia* being very characteristic of the Sound flora from this point on.

The most striking feature of the summer flora in the deeper waters at the entrance of Vineyard Sound is the presence in considerable quantity of certain species restricted wholly or almost wholly to the more open waters included in the survey. Prominent among these are *Laminaria Agardhii* var. *vittata, Laminaria digitata, Delesseria sinuosa, Lomentaria rosea, Plumaria elegans,* and *Rhodymenia palmata.* Considered as a whole, the flora at the westerly entrance of Vineyard Sound takes its chief interest from the presence of species peculiar to the cool-water sublittoral formation.

The narrow portion of Vineyard Sound will now be described. This lies between the islands of Naushon and Marthas Vineyard and may be included between a line drawn from Kopeecan Point to the west end of Naushon (Robinsons Hole) and a line from West Chop to Nobska Point. The bottom is much more varied (see chart 227) than in the westerly portion of the Sound, which in the deeper waters is almost entirely hard sand. There are, however, some extensive areas of sand adjacent to similar regions in the westerly portion of the Sound, and the region between the Middle Ground and Marthas Vineyard is likewise sandy. A few stations (7554, 7564, and 7697) presented a muddy bottom. All other stations comprising the greater part of the middle region of this portion of the Sound showed a bottom of gravel or gravel and stones. The general character of the bottom may be described as variegated, areas of gravel lying next to areas of sand or of large pebbles, the distribution of the sand being determined in all probability largely by the varied flow and scouring of the tidal currents. The greatest depths were from 15 to 17 fathoms; the average depth about 10 fathoms.

The following algæ were found in the deeper waters of this, the narrowest portion of the Sound:

Arthrocladia villosa, 7733 many; 39 and 7732, few.
Chorda filum, 7542bis, 7551, 7557, and 7559, few.
Chordaria flagelliformis, 7524 and 7525, few.
Cladostephus verticillatus, 7525bis, 7744, and 7753, few.
Desmarestia aculeata, 7739, few.
Desmarestia viridis, 7525bis, many; 7522bis, 7524bis, 7543bis, and 7549 (1907), few.
Ectocarpus siliculosis, 7525bis, few.
Laminaria Agardhii, 7525bis, many; 7524bis, 7532bis, 7533bis, 7536, 7541, 7557, 7732, 7739, 7740, and 7749, few.
Mesogloia divaricata, 7548, few.
Ralfsia clavata, 7524bis, few.
Sargassum Filipendula, 7525bis, 7533bis, 7537, 7551, 7554, 7555, 7557, 7740, 7742, 7744, 7749, and 7750, few.
Actinococcus subcutaneus, 7521bis and 7525bis, many; 7522bis and 7525bis, few.
Agardhiella tenera, 7525bis, many; 7533, 7533bis 7535, 7536, 7537, 7540, 7541, 7541bis, 7542, 7543bis, 7553, 7559, 7562, 7733, 7744, 7751, 7753, and 7754, few.
Ahnfeldtia plicata, 7524bis and 7525bis, few.
Antithamnion cruciatum, 7543bis and 7554bis, many; 7521bis, 7522bis, 7523bis, 7533bis, 7541bis, 7732, 7744, and 7745, few.
Callithamnion Baileyi, 7523, few.
Callithamnion roseum, 7521bis, 7744, and 7754, few.
Ceramium fastigiatum, 7542 and 7548, few.
Ceramium rubrum 7542, 7551, 7551 (1907), and 7557, many; 7524, 7525, 7541bis, 7548, 7554, 7559, 7560, 7565bis, 7732, 7733, 7739, 7746, and 7749, few.
Ceramium strictum, 7746, few.

Ceramium tenuissimum, 7542bis, many; 7530bis, 7541bis, 7554bis, 7559, and 7565bis, few.
Champia parvula, 7549bis, 7732, 7733, 7745, 7749, 7752, and 7754, many; 7521, 7521 (1907), 7523bis, 7525, 7525bis, 7526 (1907), 7533bis, 7534, 7541, 7541bis, 7542, 7542 (1907), 7543 (1907), 7547, 7549 (1907), 7551, 7551 (1907), 7553, 7554, 7554bis, 7557, 7559, 7560, 7562, 7565bis, 7739, 7741, 7746, and 7753, few.
Chondrus crispus, 7521 (1907), 7533bis, and 7749, many; 7523bis, 7524bis, 7525bis, 7536, 7542bis, 7554; 7554bis, 7560, 7561, 7562, 7732, 7739, and 7746, few.
Corallina officinalis, 7531bis, many.
Cystoclonium purpurascens, 7524bis, 7525bis, 7542 (1907), and 7549 (1907), few.
Cystoclonium purpurascens var. cirrhosum, 39, 7523, 7534, and 7740, few.
Dasya elegans, 7733, 7751, and 7753, few.
Delesseria sinuosa, 39, few.
Gracilaria multipartita, 7554bis, few.
Griffithsia Bornetiana, 7533bis, 7749, and 7754, few.
Grinnellia americana, 7542 and 7733, many; 7521, 7521 (1907), 7525bis, 7527, 7531bis, 7536, 7537, 7540, 7541, 7546, 7547, 7549, 7551, 7553, 7554, 7556bis, 7557, 7559, 7560, 7562, 7565bis, 7732, 7737, 7741, and 7753, few.
Hildenbrandia prototypus, 7544bis and 7547bis, many; 7533bis, 7546bis, and 7747, few.
Lithothamnion polymorphum, 7524bis, 7525bis, 7533bis, 7534bis, and 7544bis, many; 7534, 7535bis, 7539, 7539bis, and 7752, few.
Lomentaria uncinata, 7537, 7548, 7551, 7557, 7733, and 7751, few.
Melobesia Lejolisii, 7525bis, many.
Melobesia membranacea, 7739, few.
Phyllophora Brodiæi, 7521bis, 7523, 7524, 7525bis, 7526 (1907), and 7533bis, many; 7522bis, 7524bis, 7525, 7530, 7532, 7534, 7535, 7536, 7536bis, 7537, 7541, 7542 (1907), 7739, 7744, and 7749, few.
Phyllophora Brodiæi var. catenata, 7521 (1907), many.
Phyllophora membranifolia, 7521bis, 7525bis, 7531bis, 7533bis, 7739, 7740, 7742, 7744, and 7749, many; 7523bis, 7524bis, 7530 (1907), 7542bis, 7543 (1907), 7549 (1907), 7741, 7743, 7745, and 7754, few.
Polyides rotundus, 7752, many; 7526 (1907), 7532bis, 7533bis, 7536, 7541bis, 7560, 7749, and 7751, few.
Polysiphonia elongata, 7557, 7733, 7739, 7751, 7752, and 7754, few.
Polysiphonia nigrescens, 7752, many; 7523bis, 7549 (1907), 7551, and 7551 (1907), few.
Polysiphonia violacea, 7523bis, few.
Rhodomela subfusca, 7554bis, few.
Rhodymenia palmata, 7530bis, few.
Spermothamnion Turneri, 7525bis, 7533bis, and 7749, many; 7521bis, 7524, 7526 (1907), 7530bis, 7537, 7542, 7548, 7551, 7553, 7560, 7562, 7739, 7741, 7751, 7752, and 7754, few.
Spyridia filamentosa, 7530bis, 7533bis, 7542, 7559, 7562, 7741, and 7749, few.

The narrow portion of Vineyard Sound as well as the westerly portion presents some large areas practically devoid of vegetation for the reason that the bottom is sandy. The chief of these regions are around stations (7556, 7562, 7563, 7564, 7565, 7697), (7547, 7549, 7550, 7551, 7552, 7553), (7536, 7539, 7543, 7544, 7545, 7736, 7737), (7530, 7531), (7521, 7522, 7527, 7528, 7529, 7532, 7533).

The more varied character of the bottom in the deeper waters of the narrow portion of the Sound gives a larger representation of algæ, both in abundance and in number of species, than the westerly portion. Certain species appear which were not noted or were uncommon in the deeper waters of the westerly portion: *Chordaria flagelliformis, Mesogloia divaricata, Sargassum Filipendula, Ralfsia clavata, Callithamnion Baileyi, Ceramium fastigiatum, Ceramium strictum, Gracilaria multipartita, Griffithsia Bornetiana, Hildenbrandia prototypus, Lithothamnion polymorphum, Melobesia membranacea,* and *Rhodomela subfusca.*

Other species characteristic of more open waters are not present in this part of the Sound or are very rare; conspicuous among these are *Chætomorpha melagonium, Laminaria Agardhii* var. *vittata, Laminaria digitata, Delesseria sinuosa, Lomentaria rosea, Plumaria elegans,* and *Rhodymenia palmata.* Considering the list as a whole, the most striking features are the abundance and widespread distribution of *Sargassum Filipendula, Agardhiella tenera, Ceramium rubrum, Champia parvula, Chondrus crispus, Grin-*

nellia americana, Phyllophora Brodiæi, Phyllophora membranifolia, and *Spermothamnion Turneri;* these species are found at 12 or more stations each, and may be considered the dominant forms. The list in general clearly shows that the algæ of the summer in the deeper waters of the narrow portion of Vineyard Sound belong to the warm-water sublittoral formation.

The easterly portion of Vineyard Sound[a] included in this Survey is a triangular region between a line drawn from Nobska Point to West Chop and a line between Falmouth Heights and East Chop. The bottom here is much more stony than in the westerly portion of the Sound (see chart 227). While there is considerable sand in spots, there are no sandy areas so extensive as to include several stations. This region, therefore, may be described in general as gravelly, stony, and rocky, with sand in spots. The greatest depths were about 13 fathoms (chart 227), the average about 9 fathoms.

The following algæ were found in the easterly portion of the Sound:

Arthrocladia villosa, 7755, few.
Cladostephus verticillatus, 7760, 7771, and 7779, few.
Dictyosiphon hippuroides, 7760, few.
Laminaria Agardhii, 7755, 7767, 7775, and 7776, few.
Ralfsia clavata, 7780, few.
Sargassum Filipendula, 7755, 7760, 7763, 7764, 7766, 7767, 7772, 7775, 7776, 7778, 7780, 7781, and 7783, few.
Sphacelaria cirrhosa, 7760 many; 7772, few.
Agardhiella tenera, 7778 many; 7755, 7758, 7760, 7763, 7763 (1907), 7764, 7765, 7766, 7766 (1907), 7771, 7772, 7775, 7777, 7779, 7780, 7781, 7782, and 7783, few.
Ahnfeldtia plicata 7760, few.
Antithamnion cruciatum, 7764, 7768, 7770, 7772, 7773, and 7774, many; 7757, 7760, 7765, 7766, 7771, 7774, 7779, and 7780, few.
Callithamnion Baileyi, 7768 and 7772, many; 7778, few.
Callithamnion roseum, 7764, 7767, 7770, 7771, 7772, 7774, 7775, and 7776, many; 7756, 7759, 7766, 7768, 7769, 7773, 7778, 7779, 7780, 7781, and 7782, few.
Callithamnion tetragonum, 7764, 7765, and 7766, few.
Ceramium rubrum, 7755, many.
Ceramium strictum, 7763 and 7764, few.
Ceramium tenuissimum, 7777 and 7783, many; 7781, few.
Champia parvula, 7760, 7764, 7775, and 7776, many; 7756, 7757, 7758, 7759, 7763, 7763 (1907), 7765, 7766, 7767, 7769, 7770, 7771, 7772, 7774, 7777, 7778, 7779, 7780, 7781, 7782, and 7783, few.
Chondria dasyphylla, 7755, 7774, 7777, 7778, 7781, 7782, and 7783, few.
Chondrus crispus, 7764, 7766, and 7768, many; 7759, 7760, 7763 (1907), 7765, 7767, 7769, 7770, 7771, 7772, 7777, 7779, and 7781, few.
Cystoclonium purpurascens, 7760, few.
Dasya elegans, 7775, many; 7755, 7768, 7770, 7777, 7778, 7779, 7780, 7781, 7782, and 7783, few.
Gracilaria multipartita, 7766, few.
Griffithsia Bornetiana, 7755, 7778, and 7782, few.
Grinnellia americana, 7755, 7756, 7758, 7759, 7760, 7763, 7764, 7766, 7767, 7768, 7771, 7772, 7774, 7775, 7776, 7777, 7778, 7779, 7780, 7780 (1907), 7781, 7782, and 7783, few.
Hildenbrandia prototypus, 7757, 7759, 7760, 7766, 7777, 7778, and 7780, few.
Lithothamnion polymorphum, 7760, many; 7757, 7763 (1907), 7764, 7766, 7767, 7769, 7772, and 7778, few.
Lomentaria uncinata, 7760, many; 7757, 7759, 7763, 7764, 7766, 7777, 7778, 7781, and 7782, few.
Melobesia Lejolisii, 7779, 7780, and 7782, many.
Melobesia pustulata, 7768 and 7770, many; 7764 and 7765, few.
Phyllophora Brodiæi, 7763 (1907) and 7766, few.
Phyllophora membranifolia, 7770 and 7775, many; 7755, 7759, 7760, 7764, 7765, 7766, 7768, 7769, 7772, 7774, 7780, 7782, and 7783, few.
Polyides rotundus, 7759 and 7766, few.
Polysiphonia elongata, 7760, 7766, 7772, and 7780, few.
Polysiphonia fibrillosa, 7759, few.
Polysiphonia Harveyi, 7778, 7779, 7780, 7781, 7782, and 7783, few.
Polysiphonia nigrescens, 7760 and 7763 (1907), few.
Polysiphonia violacea, 7780, few.
Rhodymenia palmata, 7755, few.
Spermothamnion Turneri, 7764, 7770, 7772, and 7775, many; 7755, 7759, 7760, 7763, 7771, 7774, 7777, 7779, 7780, 7781, and 7782, few.
Spyridia filamentosa, 7776, many; 7759, 7760, 7763, 7763 (1907), and 7783, few.

[a] As stated before, this region might be considered as within the limits of Nantucket Sound if an arbitrary line were drawn between this body of water and Vineyard Sound.

The proportionate amount of algal life was very much greater in the deeper waters of this, the easterly portion of Vineyard Sound, than in the other regions, and there were no extensive barren areas. The character of the algal flora was essentially similar to that in the narrow portion of the Sound. The following species, however, present in the narrow portion, were not observed, although it is probable that all of the forms occur at times in this region:

Chorda filum.
Chordaria flagelliformis.
Desmarestia aculeata.
Desmarestia viridis.
Ectocarpus siliculosus.
Mesogloia divaricata.
Ralfsia clavata.
Actinococcus subcutaneus.
Ceramium fastigiatum.
Corallina officinalis.
Cystoclonium purpurascens var. cirrhosum.
Melobesia membranacea.
Rhodomela subfusca.

Some algæ were found which are not recorded in the previous lists: *Sphacelaria cirrhosa*, *Callithamnion tetragonum*, *Chondria dasyphylla*, *Melobesia Lejolisii*, *Polysiphonia fibrillosa*, and *Polysiphonia Harveyi*. However, most of these latter were in small quantities, and the *Melobesia Lejolisii* and *Polysiphonia Harveyi* occur in relation to beds of *Zostera*. The summer algal flora of the easterly portion of Vineyard Sound is clearly representative of the warm-water sublittoral formation.

3. CERTAIN INSHORE REGIONS OF PARTICULAR INTEREST.

It would be impossible in the limits of this paper to describe in detail the character of the vegetation along the entire coast line of Buzzards Bay and Vineyard Sound as determined from the dredgings at the inshore stations. There are, however, certain regions of particular interest because of various physiographical peculiarities, and of these the following will be briefly described: (1) Gay Head and vicinity, (2) the reefs of Sow and Pigs, (3) the passage of Woods Hole, (4) Robinsons Hole, (5) Quicks Hole, (6) Menemsha Bight, (7) Tarpaulin Cove, (8) Vineyard Haven, (9) Cove west of Cuttyhunk Neck, (10) the Middle Ground.

(1) GAY HEAD AND VICINITY.

The most interesting region in the limits of the Survey with respect to algal life is that around Gay Head. This area presents a greater luxuriance of growth and variety of species than any neighboring region, chiefly on account of the varied character of the bottom and also because a number of forms characteristic of cold waters are able to live on the exposed reefs and ledges. Conspicuous among these are *Laminaria digitata*, *Delesseria sinuosa*, *Gymnogongrous norvegicus*, *Lomentaria rosea*, *Plumaria elegans*, and *Euthora cristata*. *Euthora cristata* was dredged by W. G. Farlow off Gay Head in 8 to 10 fathoms in September, 1871, but we have not been fortunate enough to find this striking species, indicating that it is not common. The conditions under which most of the algæ of this region live are clearly those of the cool-water sublittoral formation.

The region is complex and there are at least three clearly defined zones. The first zone (stations 50 and 51) is in shallow water and includes large rocks, some of which rise above the water, with sandy areas between them. The second zone (stations 44

to 49) comprises various reefs that lie off Gay Head, and especially the ledge known as Devils Bridge; these rocks are in 2 to 5 fathoms and the bottom between them is sandy. The third zone (stations 56–60, 7581 and 7731) is in deeper water outside of the reefs and has a rocky, gravelly, or sandy bottom in 5 to 12 fathoms. These zones will be considered in order.

The first zone (stations 50 and 51) in shallow water was studied August 9, 1904. It comprised the following species, chiefly growing on rocks:

Calothrix scopulorum (on piles).
Chætomorpha area (on piles).
Cladophora albida var. refracta.
Enteromorpha intestinalis.
Enteromorpha prolifera.
Ulva Lactuca var. rigida.
Chorda filum.
Chordaria flagelliformis.
Desmotrichum undulatum (on Zostera).
Ectocarpus fasciculatus (on larger algæ).
Ectocarpus siliculosus (on larger algæ).
Fucus evanescens.
Fucus vesiculosus.
Fucus vesiculosus var. sphærocarpus.
Laminaria Agardhii.
Laminaria digitata.
Phyllitis fascia.
Scytosiphon lomentarius.
Ahnfeldtia plicata.
Callithamnion Baileyi (on Chondrus).
Ceramium rubrum (on Chondrus).
Champia parvula.
Chondrus crispus.
Cystoclonium purpurascens var. cirrhosum.
Nemalion multifidum.
Pleonosporium Borreri (on larger algæ).
Polysiphonia fibrillosa.
Polysiphonia nigrescens.
Polysiphonia violacea.
Rhodomela subfusca (on piles).
Rhodymenia palmata.
Spermothamnion Turneri.

The second zone (stations 44 to 49) was also studied August 9, 1904. The list of species is as follows:

Chætomorpha melagonium, 44 and 45, few.
Chorda filum, 47 and 49, few.
Desmarestia aculeata, 46, 47, and 48, few.
Desmarestia viridis, 46, few.
Ectocarpus siliculosus, 44 and 45, few.
Laminaria Agardhii, 44, 45, 46, 47, and 49, few.
Laminaria Agardhii var. vittata, 44, 45, and 47, few.
Laminaria digitata, 44 and 48, few.
Ahnfeldtia plicata, 47 and 49, many; 44, 46, and 48, few.
Ceramium fastigiatum, 44, few.
Ceramium rubrum, 44, 45, 46, 47, and 48, few.
Champia parvula, 49, many; 44, 46, and 47, few.
Chondrus crispus, 44, 45, 46, 47, 48, and 49, many.
Corallina officinalis, 47, many; 44, 45, and 48, few.
Cystoclonium purpurascens, 44 and 49, many.
Cystoclonium purpurascens var. cirrhosum, 44, 45, 46, and 47, many; 48 and 49, few.
Delesseria sinuosa, 45, many; 46, few.
Grinnellia americana, 49, few.
Lomentaria rosea, 45, few.
Melobesia pustulata, 45, 46, 47, and 49, many; 44, few.
Phyllophora Brodiæi, 45, many; 44, 46, 47, 48, and 49, few.
Plumaria elegans, 44, few.
Polyides rotundus, 46, 47, and 48, many; 44, few.
Polysiphonia elongata, 44 and 45, many; 46, 47, 48, and 49, few.
Polysiphonia nigrescens, 49, many; 47, rew.
Polysiphonia violacea, 45 and 48, few.
Rhodymenia palmata, 45, 46, and 47, many; 44 and 48, few.
Seirospora Griffithsiana, 49, few.
Spermothamnion Turneri, 44, 45, and 46, many; 47 and 49, few.

The third zone (stations 56–60, 7581 and 7731) was studied August 15, 1904. The following list includes the species of the seven stations:

Chætomorpha melagonium, 56, 57, 58, and 60, few.
Arthrocladia villosa, 56, many.
Desmarestia aculeata, 57, many; 56, 59, 60, and 7731, few.
Desmarestia viridis, 57, 58, 7731, and 7731 (1907), many; 59, few.
Laminaria Agardhii, 57, 59, 60, 7581 (1907), and 7731, few.
Laminaria Agardhii var. vittata, 57 and 7731, many; 59 and 60, few.
Ralfsia clavata, 57, many; 56, 58, and 59, few.
Ahnfeldtia plicata, 60, few.

Antithamnion cruciatum, 56, few.
Antithamnion plumula, 57 and 58, few.
Callithamnion roseum, 57, few.
Ceramium rubrum, 57 and 7731, many; 59 and 7731 (1907), few.
Chondrus crispus, 56, 57, and 58, many; 59, 60, 7581 (1907), and 7731 (1907), few.
Corallina officinalis, 56 and 57, many; 58, 60, and 7581, few.
Cystoclonium purpurascens, 56, 57, 58, and 59, many; 60, few.
Cystoclonium purpurascens var. cirrhosum, 56, 58, 59, and 7731 (1907), many; 60, 7581 (1907), and 7731, few.
Delesseria sinuosa, 56, 57, and 58, many; 7731, few.
Grinnellia americana, 56, many; 7581, few.
Gymnogongrus norvegicus, 56, few.
Hildenbrandia prototypus, 58 and 59, many.
Lithothamnion polymorphum, 57, 58, 59, and 60, many.
Lomentaria rosea, 57 and 58, many; 56 and 59, few.
Melobesia farinosa, 57 and 58, many.
Melobesia membranacea, 56, 57, and 58, many.
Melobesia pustulata, 57, few.
Phyllophora Brodiæi, 56, 57, and 58, many; 59, few.
Phyllophora membranifolia, 56, 57, and 58, many; 60, few.
Plumaria elegans, 57, 58, and 59, many.
Polyides rotundus, 56, 57, 58, 60, and 7581 (1907), few.
Polysiphonia atrorubescens, 56, many.
Polysiphonia elongata, 56, 59, and 7731, many; 60, 7581 (1907), and 7731 (1907), few.
Polysiphonia nigrescens, 60 and 7731, many; 59, 7581 (1907), and 7731 (1907), few.
Rhodomela subfusca, 56, few.
Rhodomela Rochei, 7731 (1907), few.
Rhodymenia palmata, 59, many; 60 and 7731 (1907), few.
Scinaia furcellata, 57, few.
Spermothamnion Turneri, 56, 57, and 58, many; 59, few.

(2) THE REEFS OF SOW AND PIGS.

The bottom around the reefs of Sow and Pigs (stations 35, 36 and 37), lying off Cuttyhunk, has an algal flora noteworthy for the presence of such species as *Delesseria sinuosa*, *Lomentaria rosea*, and *Plumaria elegans*, forms which are also characteristic of the ledges off Gay Head and are members of the cool-water sublittoral formation. The quantity of algæ is, however, not great. An examination of the reefs themselves, although difficult, would doubtless prove interesting. There were considerable amounts of *Corallina officinalis* (35, 36, 37), *Delesseria sinuosa* (35, 36), *Phyllophora Brodiæi* (35, 36, 37), and *Plumaria elegans* (36, 37), and in addition relatively few plants of *Chætomorpha melagonium* (37), *Ectocarpus fasciculatus* (37), *Laminaria Agardhii* var. *vittata* (36, 37), *Ahnfeldtia plicata* (36), *Ceramium rubrum* (37), *Ceramium tenuissimum* (35), *Chondrus crispus* (35, 36), *Cystoclonium purpurascens* var. *cirrhosum* (35, 36, 37), *Lithothamnion polymorphum* (35), *Lomentaria rosea* (37), *Melobesia pustulata* (36), *Rhodymenia palmata* (36), and *Spermothamnion Turneri* (35).

(3) THE PASSAGE OF WOODS HOLE.

The easterly side of the passage of Woods Hole (station 122) off the end of the hook-shaped point of land called Penzance (Long Neck) has a sand and gravel bottom in 4 to 5 fathoms. The following species were found in small quantities: *Champia parvula*, *Dasya elegans*, *Griffithsia Bornetiana*, *Grinnellia americana*, *Phyllophora Brodiæi*, *Polysiphonia nigrescens*, *Rhodomela Rochei*, and *Seirospora Griffithsiana*.

The westerly side of the passage off Uncatena Island (station 118) on a bottom of sand and shells showed small quantities of *Chordaria flagelliformis*, *Ceramium rubrum*, *Chondrus crispus*, *Cystoclonium purpurascens*, and *Lomentaria uncinata*. Off the entrance to Hadley Harbor (stations 119 and 120) the bottom is sand and mud, and appears to support no algal life.

The main channel near Hadley Rock (station 121) has a bottom of sand and stones. There was an abundance of *Laminaria Agardhii*, *Agardhiella tenera*, *Chondrus crispus*, and *Gracilaria multipartita*, together with a few plants of *Sargassum Filipendula*. Dredgings of previous years have shown that *Callithamnion roseum* grows on shells in the narrower portion of the passage (Woods Hole proper), and also *Scinaia furcellata*. The passage on the south is bordered by ledges, chiefly submerged, and these are covered with heavy growths of algæ. The reader may obtain a general idea of the character of the algal life on these rocks bordering the channel from chapter IV, page 476, "A Report on the Algæ of Spindle Rocks, Woods Hole Harbor," a small group of rocks (destroyed in the summer of 1905) that formerly lay between Grassy Ledge and Red Ledge. These submerged ledges are difficult to study, but detailed examinations of some of them carried on through various seasons of the year would undoubtedly give some interesting results.

The algal life on the bottom of the harbor of Woods Hole and in the two ships' channels that lead into it from Vineyard Sound on either side of Great Ledge is very sparse. The bottom is hard sand and sandy mud, unfavorable for extensive growths of algæ. A haul (station 4) inside of Great Ledge in 2 to 5 fathoms over a sandy bottom gave a few plants of *Antithamnion cruciatum*, *Ceramium rubrum*, *Chondrus crispus*, *Gracilaria multipartita*, *Grinnellia americana*, *Melobesia Lejolisii* (on *Zostera*), and *Phyllophora Brodiæi*.

(4) ROBINSONS HOLE.

Robinsons Hole, along the west end of Naushon (stations 20, 21 and 22), has a rich algal flora over a stony bottom in 2 to 3½ fathoms. There was an abundance of:

Chorda filum, 21 and 22.
Desmarestia aculeata, 20, 21 and 22.
Desmarestia viridis, 20 and 22.
Laminaria Agardii var. vittata, 21.
Antithamnion cruciatum, 22.
Ceramium fastigiatum, 20.
Ceramium rubrum, 20, 21 and 22.
Chondrus crispus, 20, 21 and 22.
Cystoclonium purpurascens, 20 and 22.
Cystoclonium purpurascens var. cirrhosum, 20 and 22.
Hildenbrandia prototypus, 21 and 22.
Lithothamnion polymorphum, 21.
Phyllophora Brodiæi, 20, 21 and 22.
Phyllophora membranifolia, 22.
Rhodymenia palmata, 21 and 22.
Scinaia furcellata, 21.
Spermothamnion Turneri, 20

In small quantities were found:

Cladophora gracilis, 20 and 21.
Cladostephus verticillatus, 21.
Ectocarpus siliculosus, 21.
Laminaria Agardhii, 22.
Leathesia difformis, 20.
Phyllitis fascia, 22.
Ahnfeldtia plicata, 21 and 22.
Ceramium strictum, 20.
Champia parvula, 20, 21 and 22.
Corallina officinalis, 20 and 21.
Dasya elegans, 21.
Lomentaria uncinata, 21 and 22.
Polysiphonia fibrillosa, 20.
Polysiphonia nigrescens, 20 and 22.

Station 23, off the island of Pasque, at the entrance to Robinsons Hole, showed the presence of much *Antithamnion cruciatum*, *Chondrus crispus*, *Phyllophora membranifolia*, *Rhodymenia palmata*, and a few plants of *Desmarestia aculeata*, *Desmarestia viridis*, and *Polysiphonia elongata*.

This flora has a mixed composition including forms characteristic of both the cool- and warm-water sublittoral formations, indicating that the summer conditions of Robinsons Hole are somewhat midway between those of the open and those of the sheltered waters of the Sound and Bay.

(5) QUICKS HOLE.

Quicks Hole does not have so luxuriant a vegetation as Robinsons Hole, probably because the bottom is not so rocky. On the easterly side (station 27), along the west end of Pasque, in 4 to 5 fathoms over a rocky bottom, there was a rich growth of *Desmarestia aculeata*, *Laminaria Agardhii* var. *vittata*, *Callithamnion Baileyi*, *Phyllophora Brodiæi*, *Rhodymenia palmata*, and a few plants were found of *Desmarestia viridis* and *Cystoclonium purpurascens* var. *cirrhosum*. The westerly side (station 28 and 29) has a sandy bottom in 3 to 5 fathoms, with quite a different vegetation. There were found in abundance *Chorda filum* (station 29), *Desmarestia aculeata* (station 29), *Desmotrichum undulatum* (station 29, on *Zostera*), *Ectocarpus siliculosus* (station 29, on *Zostera*), *Melobesia Lejolisii* (station 29, on *Zostera*), and *Spermothamnion Turneri*. The following were found in small quantities:

Chordaria flagelliformis, 29.
Laminaria Agardhii, 28.
Leathesia difformis, 29.
Agardhiella tenera, 28.
Chondrus crispus, 29.
Corallina officinalis, 29.
Cystoclonium purpurascens, 29.
Hildenbrandia prototypus, 28.
Lithothamnion polymorphum, 28.
Polysiphonia elongata, 29.
Polysiphonia fibrillosa, 29.
Rhodomela subfusca, 29.

(6) MENEMSHA BIGHT.

A special trip to Menemsha Bight was made on July 17, 1905, in the *Genevieve* of the Marine Biological Laboratory. Three hauls were taken, (1) at the east end of Menemsha Bight just outside of the fish traps, bottom sandy in 6½ fathoms; (2) in the middle region between the fish traps, bottom sandy mud in 5½ fathoms; and (3) about three-fourths of a mile offshore at the west end of Menemsha Bight, bottom sandy in 8½ fathoms. The following species were recorded:

Chætomorpha Linum, 3, few.
Desmarestia viridis, 2, many; 1 and 3, few.
Laminaria Agardhii, 1, 2 and 3, few.
Ralfsia clavata, 3, few.
Sargassum Filipendula, 1, few.
Agardhiella tenera, 1, many.
Antithamnion cruciatum, 1, few.
Antithamnion plumula, 1 and 2, few.
Callithamnion roseum, 2, few.
Ceramium rubrum, 2, few.
Champia parvula, 3, few.
Cystoclonium purpurascens var. cirrhosum, 2, many.
Hildenbrandia prototypus, 1 and 3, few.
Phyllophora Brodiæi, 2, few.
Polysiphonia atrorubescens, 2, few.
Polysiphonia elongata, 2 and 3, many.
Polysiphonia fibrillosa, 2, few.
Polysiphonia nigrescens, 1, 2 and 3, very abundant.
Seirospora Griffithsiana, 1, 2 and 3, few.
Spyridia filamentosa, 1, few.

The most remarkable feature of this locality was the great quantity of *Polysiphonia nigrescens*. The flora of these sheltered waters was clearly representative of the warm-water sublittoral formation, a fact of some interest considering its proximity to Gay Head.

An examination in the *Blue Wing* of the shallow waters of Menemsha Bight, off Lobsterville, on August 9, 1904, showed a bottom of sandy mud in 3 fathoms. *Zostera* was plentiful in spots and seems to be establishing itself in this region; there was very little present four or five years previous (Vinal Edwards). There were great quantities of *Ectocarpus siliculosus* as well as *Melobesia Lejolisii* covering the *Zostera*, and a few plants of the following were found: *Agardhiella tenera*, *Chondrus crispus*, and *Cystoclonium purpurascens* var. *cirrhosum*.

(7) TARPAULIN COVE.

Tarpaulin Cove proved interesting in several respects. The westerly side (station 17) has a bottom of sand and gravel in 2½ to 4 fathoms, and there was an abundance of *Desmarestia viridis* and *Antithamnion cruciatum*, and in small quantities *Cladophora gracilis*, *Agardhiella tenera*, *Antithamnion plumula*, *Callithamnion Baileyi*, and *Grinnellia americana;* the dredge brought up large quantities of *Zostera*. The upper end of the cove (station 18) in 2½ fathoms has a bottom of mud and gravel supporting extensive beds of *Zostera*, and an abundance of *Polysiphonia nigrescens*. A line dredged across the entrance of the cove (station 19) showed a muddy bottom with occasional plants of *Polysiphonia nigrescens*. Hauls made at the entrance nearest the lighthouse, July 18, 1903 (Phalarope), showed the presence of much *Seirospora Griffithsiana* and small quantities of *Desmarestia viridis*, *Laminaria Agardhii*, *Agardhiella tenera*, *Callithamnion Baileyi*, *Ceramium fastigiatum*, *Ceramium rubrum*, *Champia parvula*, and *Grinnellia americana*.

(8) VINEYARD HAVEN.

Station 69 off West Chop, at the entrance to Vineyard Haven, was very rich in algæ and especially interesting as a locality for *Rhadinocladia Farlowii*. The bottom was sand and stones in 3½ to 7 fathoms and supported extensive growths of *Zostera*. There was much of the following:

Ralfsia clavata.
Rhadinocladia Farlowii (on Zostera).
Sphacelaria radicans.
Agardhiella tenera.
Antithamnion cruciatum.
Callithamnion roseum.
Ceramium tenuissimum.
Hildenbrandia prototypus.
Lomentaria uncinata.
Melobesia farinosa.
Melobesia Lejolisii.
Phyllophora Brodiæi.
Phyllophora membranifolia.
Spermothamnion Turneri.

In small quantitles were:

Cladostephus vertillatus.
Desmotrichum undulatum.
Ectocarpus confervoides.
Sphacelaria cirrhosa.
Ahnfeldtia plicata.
Callithamnion corymbosum.
Dasya elegans.
Lithothamnion polymorphum.
Polyides rotundus.
Spyridia filamentosa.

Vineyard Haven proper (stations 70, 71, 72, and 7762) presented little variety in its algal life but considerable quantities of certain species. Station 70 in 4 fathoms, with a bottom of stones and *Crepidula* shells, gave much *Agardhiella tenera*, *Champia parvula*, *Grinnellia americana*, and *Lomentaria uncinata;* in small quantities were *Rhadinocladia Farlowii* (on *Zostera*), *Antithamnion cruciatum*, *Callithamnion corymbosum*, *Ceramium strictum*, *Ceramium tenuissimum*, *Hildenbrandia prototypus*, *Lithothamnion polymorphum*, and *Melobesia Lejolisii*. Station 71, with a bottom of clam and pecten shells, stones, and mud, in 3½ fathoms, gave an abundance of *Sphacelaria radicans*, *Agardhiella tenera*, *Champia parvula*, *Grinnellia americana*, *Lomentaria uncinata*, and *Phyllophora Brodiæi*. Station 72, stones and mud, in 3 to 4 fathoms, showed large quantities of *Calothrix confervicola*, *Sphacelaria cirrhosa*, *Agardhiella tenera*, *Champia parvula*, *Lomentaria uncinata*, *Melobesia Lejolisii*, and *Spermothamnion Turneri*, and a few plants

of *Enteromorpha clathrata*, *Sphacelaria radicans*, *Grinnellia americana*, and *Polysiphonia Harveyi*. Station 7762, in the middle of Vineyard Haven, had a bottom of mud and shells in 3½ to 4 fathoms; there was an abundance of *Agardhiella tenera*, *Champia parvula*, *Grinnellia americana*, *Lomentaria uncinata*, and small quantities of *Dictyosiphon hippuroides*, *Sargassum Filipendula*, *Phyllophora membranifolia*, *Polysiphonia elongata*, *Spermothamnion Turneri*, and *Spyridia filamentosa*. The bottom of such a harbor as Vineyard Haven always receives large quantities of drifted algæ, some of which are able to vegetate loosely over the bottom; conspicuous among these are *Champia parvula*, *Lomentaria uncinata*, and *Spermothamnion Turneri*. The shallow regions support extensive beds of *Zostera marina*.

Station 7761, off East Chop at the entrance to Vineyard Haven, with a bottom of sand, cinders, and shell fragments in 6 to 7 fathoms, gave much *Sargassum Filipendula*, *Sphacelaria cirrhosa*, *Agardhiella tenera*, *Callithamnion roseum*, *Champia parvula*, *Lomentaria uncinata*, *Phyllophora membranifolia*, and *Spermothamnion Turneri;* in small quantities were *Chordaria flagelliformis*, *Cladostephus verticillatus*, *Dictyosiphon hippuroides*, *Laminaria Agardhii*, *Chondrus crispus*, *Griffithsia Bornetiana*, *Grinnellia americana*, *Lithothamnion polymorphum*, *Phyllophora Brodiæi*, *Polyides rotundus*, *Polysiphonia nigrescens*, *Rhodymenia palmata*, and *Spyridia filamentosa*.

(9) COVE WEST OF CUTTYHUNK NECK.

A cove west of Cuttyhunk Neck (station 101) proved to be one of the most interesting stations in Buzzards Bay because of the abundance of *Arthrocladia villosa*. A special trip was made July 27, 1905, on the *Genevieve* of the Marine Biological Laboratory, one week after this station was discovered, to determine more precisely the habits of this interesting alga. Four hauls were carried across the entrance of the cove from southwest to northeast in 4 to 5 fathoms. The bottom was sandy, with quantities of large clam shells (*Venus mercenaria*), mussel shells, and pebbles, to which the *Arthrocladia* was attached in great abundance. The plants were very large and in full fruit and supplied the set distributed in the Phycotheca Boreali-Americana, fas. D, no. XXX. Besides the *Arthrocladia*, there was much *Desmarestia aculeata*, *Laminaria Agardhii* var. *vittata*, *Cystoclonium purpurascens* var. *cirrhosum*, *Grinnellia americana*, *Phyllophora Brodiæi*, and *Polysiphonia elongata*. In small quantities were found *Chorda filum*, *Desmarestia viridis*, *Dictyosiphon hippuroides*, *Ectocarpus siliculosus*, *Laminaria Agardhii*, *Antithamnion cruciatum*, *Callithamnion roseum*, *Corallina officinalis*, *Polyides rotundus*, and *Scinaia furcellata*.

(10) THE MIDDLE GROUND.

The shallow stretch in Vineyard Sound, known as the Middle Ground (stations 41, 42, and 43), has a bottom of sand and broken shells, 2 to 4½ fathoms at station 41, 3½ to 6 fathoms at station 42, and 2½ to 5 fathoms at station 43. There was no evidence of algal life, and it is probably quite safe to say that no algæ grow on these banks of shifting sand scoured by tidal currents.

4. SOME STATISTICS RELATIVE TO THE DISTRIBUTION OF ALGÆ IN BUZZARDS BAY AND VINEYARD SOUND.

It is a very difficult matter to make in detail a satisfactory comparison of the algal flora of Woods Hole and its vicinity with those of other coasts, chiefly for the reason that the life conditions are so diverse in different sections of the region and at different seasons that there are in reality several floras to be considered. These have been described in the account of the principal formations which may be distinguished (section II, chapter III, pages 468–475), but far more must be known of their composition and habits at other seasons of the year than the summer before their limits can be defined with exactness. The general characteristics of the summer flora of the warmer waters of the region, which is a part of the flora of Long Island Sound, are outlined in the introduction to section II, chapter I, pages 443 and 444.

Comparative studies of algal floras are also rendered very difficult because the floras have generally been described more with regard to the variety and number of species than with respect to the quantities of the dominant forms. A comparison of two lists of species may show that a very large proportion, perhaps a majority of the forms, are not the same, and yet when judged quantitatively, i. e., by the total mass of vegetation composed of species common to both, the two floras might be considered as essentially similar. We have examined lists of species published by surveys or from stations on the Scandanavian coast, the Faroes, Denmark, Clyde Sea area, Plymouth, the Irish Sea, Naples, etc., and considered the possibility of drawing up comparative tables of floras, but we must confess that to us there seemed so little promise of satisfactory results that the work was not undertaken.

In connection with the zoological data presented in section I, chapter III, statistics were tabulated for the distribution of the four classes of algæ and of *Zostera marina* as determined by the dredging operations in Buzzards Bay and Vineyard Sound. The results of that tabulation are presented below. Of especial interest are the statistics for the quantity of vegetation over three types of bottom: Division A, "sand," including bottoms recorded as pure sand or sand and shells (excluding bottoms containing stones, gravel, or mud); division B, "gravel and stones," including records which list either of these ingredients singly, or in combination with one another or with sand (excluding bottoms containing mud); division C, "mud," including bottoms recorded as of mud, muddy sand, or sandy mud (excluding bottoms containing gravel or stones, but including those in which shells are listed). Finally there is presented a table which lists those species that were of such general distribution as to occur at one-fourth or more of the total number of stations, at one-fourth or more of the stations dredged by the *Fish Hawk* and *Phalarope* in both the Bay and Sound, and at one-fourth of the stations of the three types of bottom designated as A, B, and C. These tables follow in the order outlined above.

AVERAGE NUMBER OF GENERA AND SPECIES OF PLANTS TAKEN PER DREDGE HAUL FOR THE 458 STATIONS OF THE REGULAR SERIES.

Groups.	Genera.	Species.
Cyanophyceæ	0.004	0.004
Chlorophyceæ	.09	.1
Phæophyceæ	1.1	1.3
Rhodophyceæ	4.3	4.6
Zostera marina	.1	.1

AVERAGE NUMBER OF GENERA AND SPECIES OF PLANTS TAKEN PER DREDGE HAUL AT THE FISH HAWK STATIONS.

Groups.	Vineyard Sound.		Buzzards Bay.	
	Genera.	Species.	Genera.	Species.
Chlorophyceæ	0.02	0.02	0.05	0.05
Phæophyceæ	.9	1.0	1.1	1.1
Rhodophyceæ	3.4	3.6	2.8	3.0
Zostera marina	.1	.1	.1	.1

AVERAGE NUMBER OF GENERA AND SPECIES OF PLANTS TAKEN PER DREDGE HAUL AT THE PHALAROPE AND BLUE WING STATIONS (INSHORE).

Groups.	Vineyard Sound.		Buzzards Bay.	
	Genera.	Species.	Genera.	Species.
Cyanophyceæ	0.03	0.03	...	...
Chlorophyceæ	.3	.3	0.1	0.1
Phæophyceæ	1.8	2.2	1.2	1.3
Rhodophyceæ	7.7	8.4	4.8	5.2
Zostera marina	.3	.3	.2	.2

AVERAGE NUMBER OF GENERA AND SPECIES OF PLANTS TAKEN AT EACH OF THE FOREGOING GROUPS OF STATIONS, THE CLASSES BEING COMBINED.

	Stations.	Genera.	Species.
Fish Hawk:			
Vineyard Sound	218	4.5	4.7
Buzzards Bay	66	4.0	4.2
Phalarope (and Blue Wing):			
Vineyard Sound, inshore	77	10.1	11.3
Buzzards Bay, inshore	90	6.3	6.8
Total	451	5.7	6.2

AVERAGE NUMBER OF GENERA AND SPECIES OF PLANTS TAKEN UPON BOTTOMS OF "SAND," DIVISION A (170 STATIONS).

Groups.	Genera.	Species.
Cyanophyceæ	0.006	0.006
Chlorophyceæ	.1	.1
Phæophyceæ	1.3	1.4
Rhodophyceæ	4.0	4.3
Zostera marina	.1	.1

Average Number of Genera and Species of Plants Taken Upon Bottoms of "Gravel and Stones," Division B (167 Stations).

Groups.	Genera.	Species.
Chlorophyceæ	0.09	0.09
Phæophyceæ	1.2	1.3
Rhodophyceæ	5.6	6.0
Zostera marina	.1	.1

Average Number of Genera and Species of Plants Taken Upon Bottoms of "Mud," Division C (112 Stations).

Groups.	Genera.	Species.
Cyanophyceæ	0.009	0.009
Chlorophyceæ	.1	.1
Phæophyceæ	.9	1.0
Rhodophyceæ	2.8	3.0
Zostera marina	.2	.2

Species Dredged at One-fourth or More of the Stations.

[The figures at the top of the columns represent one-fourth of the total number of stations in each group.]

Species.	115 Total stations.	55 Fish Hawk, Sound.	17 Fish Hawk, Bay.	19 Phalarope, Sound.	23 Phalarope, Bay.	43 Bottom A, "sand."	42 Bottom B, "gravel and stones."	28 Bottom C, "mud."
Phæophyceæ:								
Desmarestia aculeata	...	...	...	20	...	...	...	...
Desmarestia viridis	...	...	...	19	...	...	...	...
Laminaria Agardhii	...	...	...	20	...	...	...	...
Rhodophyceæ:								
Agardhiella tenera	...	...	...	25	32	...	52	...
Antithamnion cruciatum	...	...	...	29	...	...	46	...
Champia parvula	139	75	...	28	23	49	67	...
Chondrus crispus	...	...	...	42	...	...	55	...
Corallina officinalis	...	...	...	20	...	...	...	...
Cystoclonium purpurascens	...	...	...	19	...	...	...	...
Cystoclonium purpurascens var. cirrhosum	...	...	...	30	...	...	...	...
Grinnellia americana	140	62	20	27	31	50	60	29
Lithothamnion polymorphum	...	...	...	19	...	...	...	...
Phyllophora Brodiæi	...	...	...	47	23	...	59	...
Phyllophora membranifolia	...	...	...	19	38	...	59	...
Polyides rotundus	...	...	...	25	...	...	...	...
Polysiphonia elongata	...	...	...	19	...	...	...	...
Polysiphonia nigrescens	...	...	...	26	...	...	...	...
Spermothamnion Turneri	...	...	...	36	...	...	44	...
Spermatophyta:								
Zostera marina	...	...	...	19	...	...	...	...

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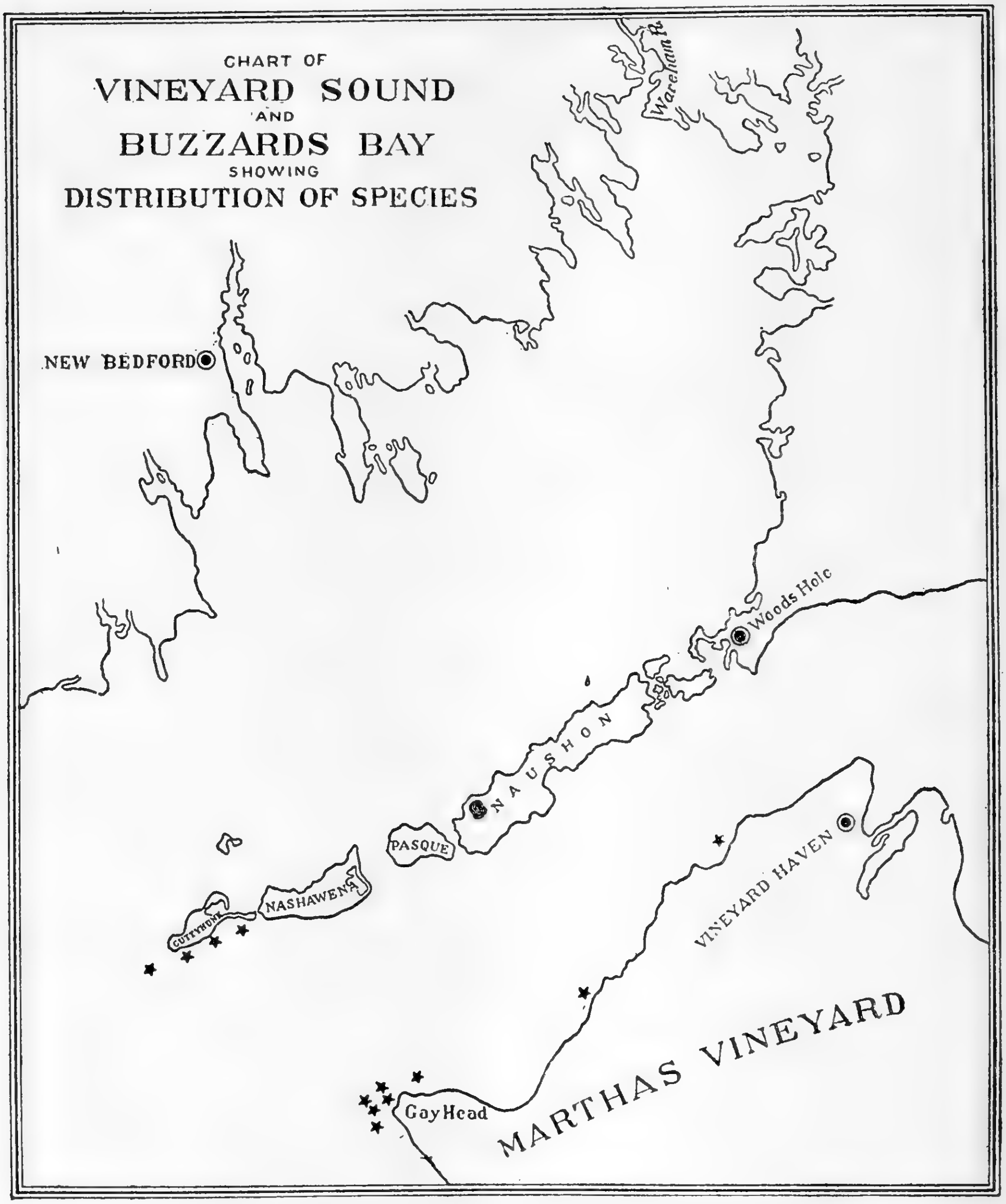

CHART 228.—Chætomorpha melagonium (Weber & Mohr) Kützing.

Present in the deeper and cooler waters off exposed points, such as Gay Head and Cuttyhunk.

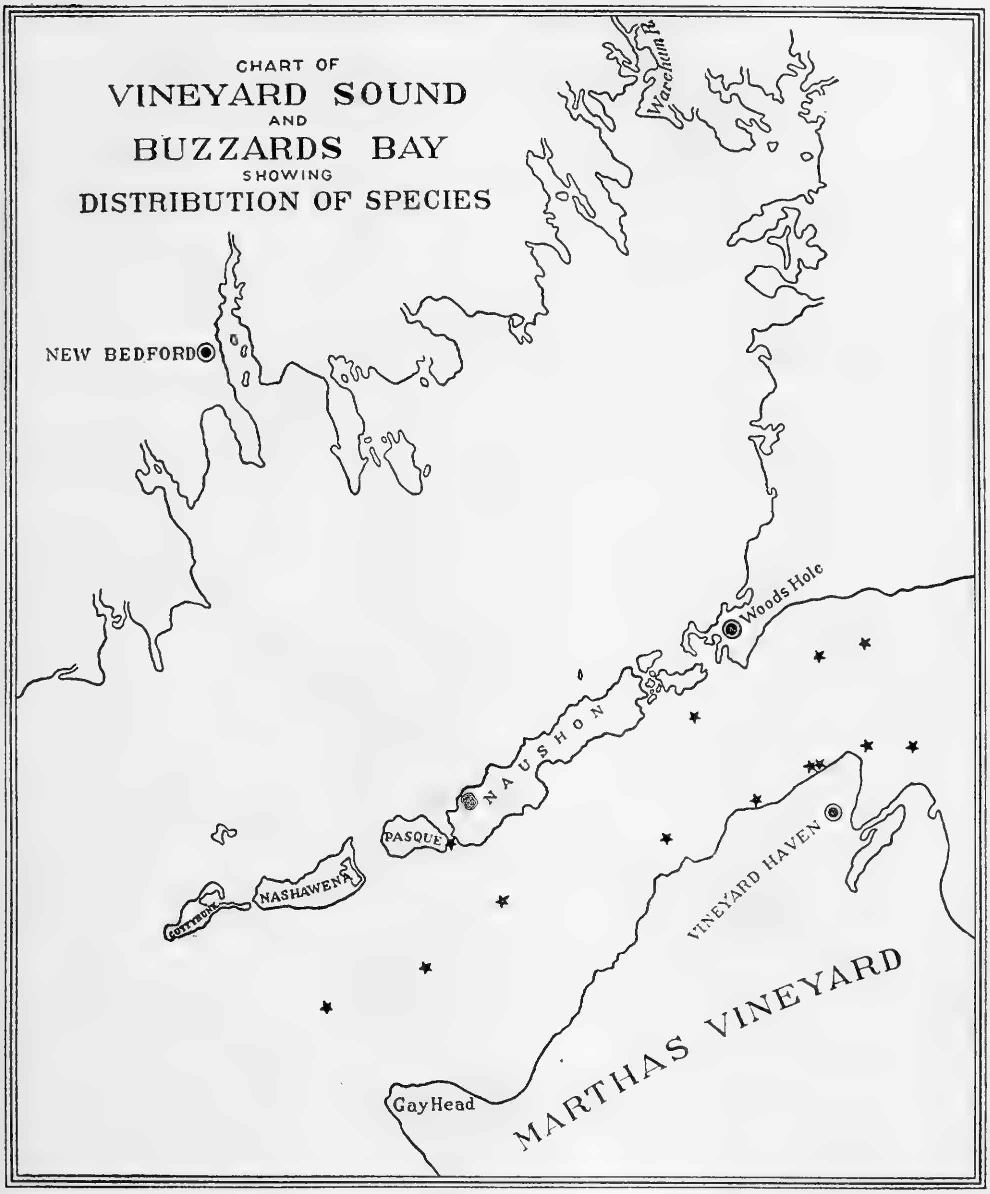

CHART 229.—Cladostephus verticillatus (Lightfoot) Agardh.

A scattered distribution throughout Vineyard Sound in fairly deep water.

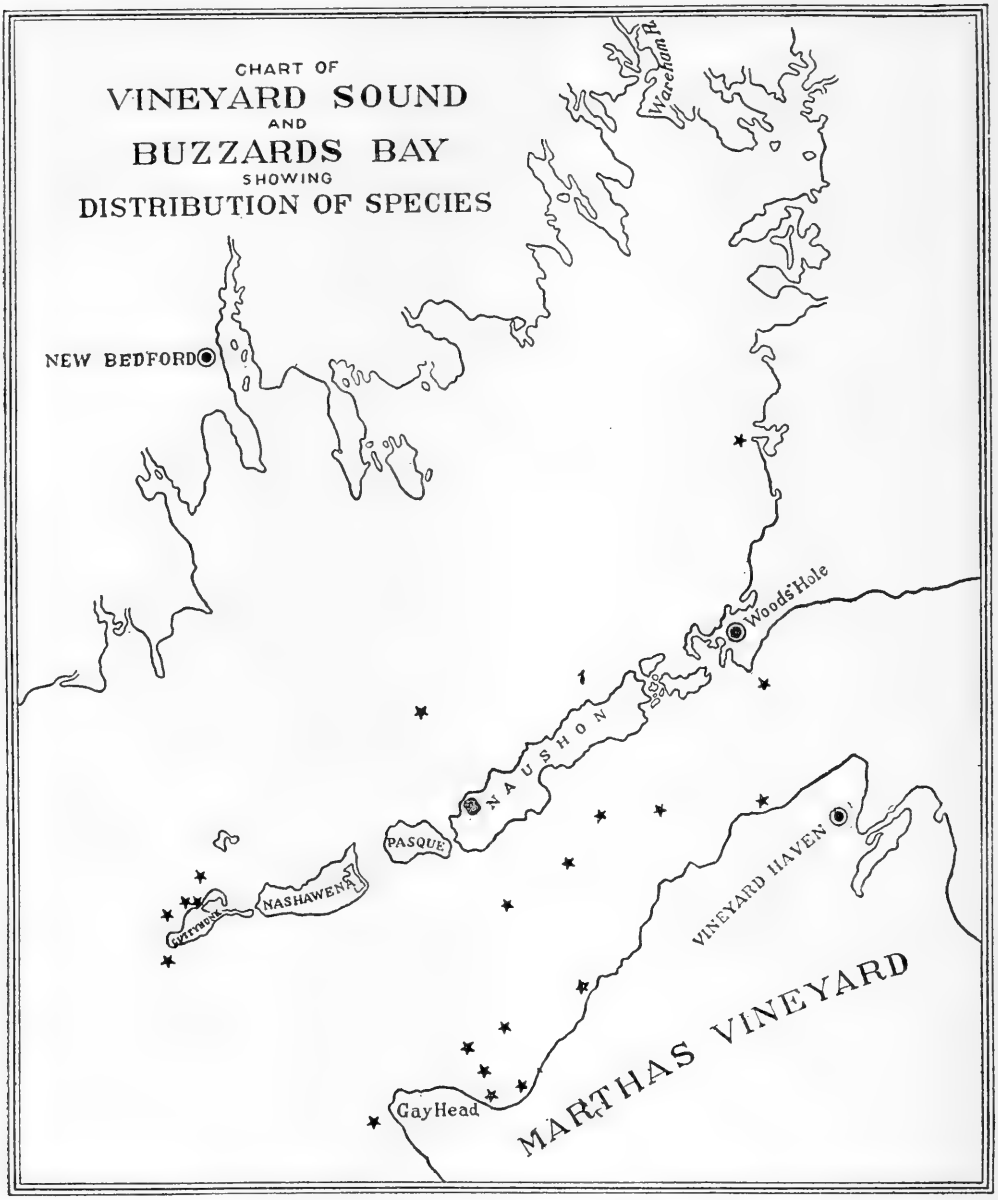

CHART 230.—Arthrocladia villosa (Hudson) Duby.

This species, formerly considered rather rare, is widely distributed and at certain stations even plentiful.

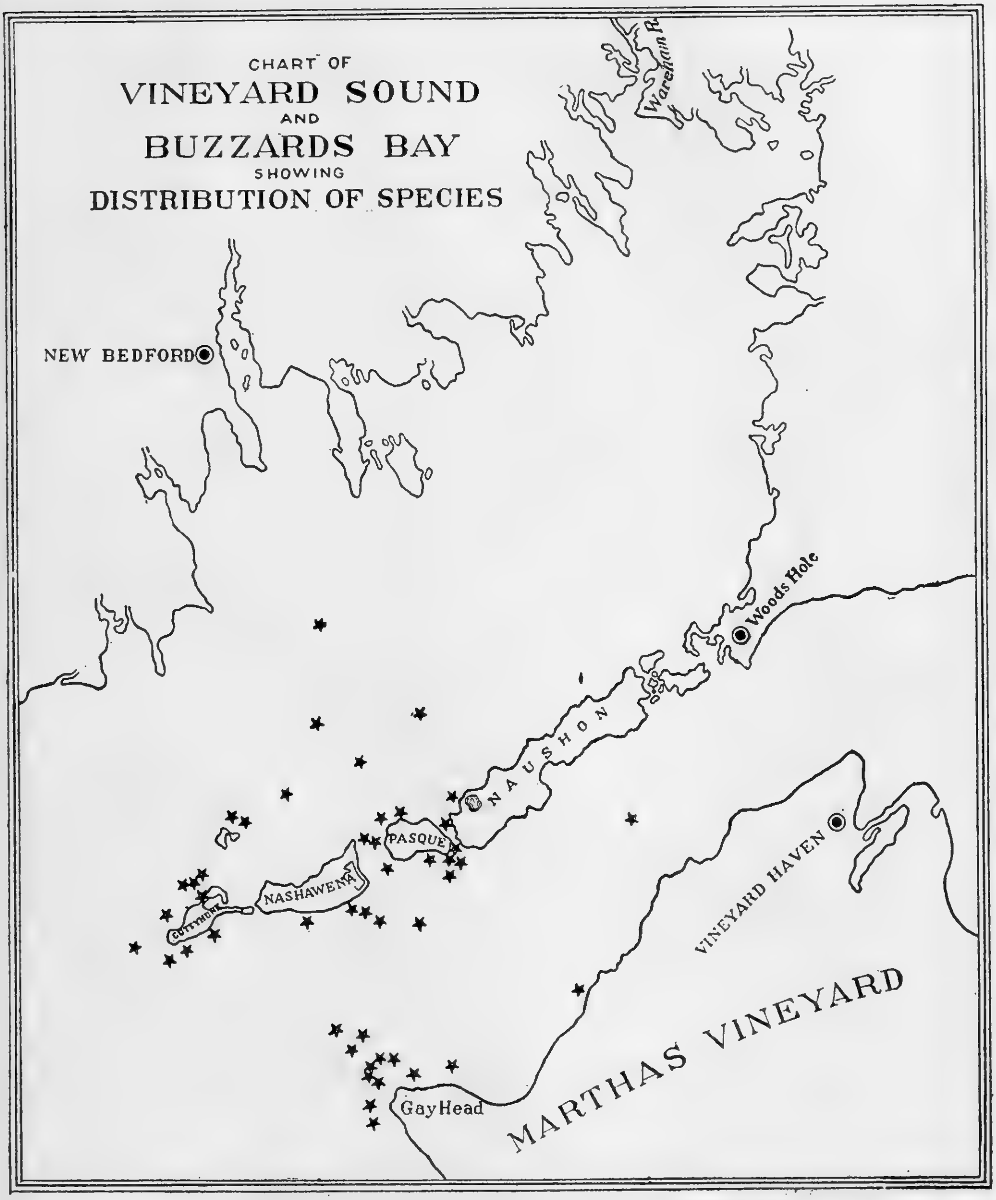

CHART 231.—Desmarestia aculeata (Linnæus) Lamouroux.

This large species is almost restricted to the deeper and cooler waters of the lower portion of Buzzards Bay and westerly portion of Vineyard Sound.

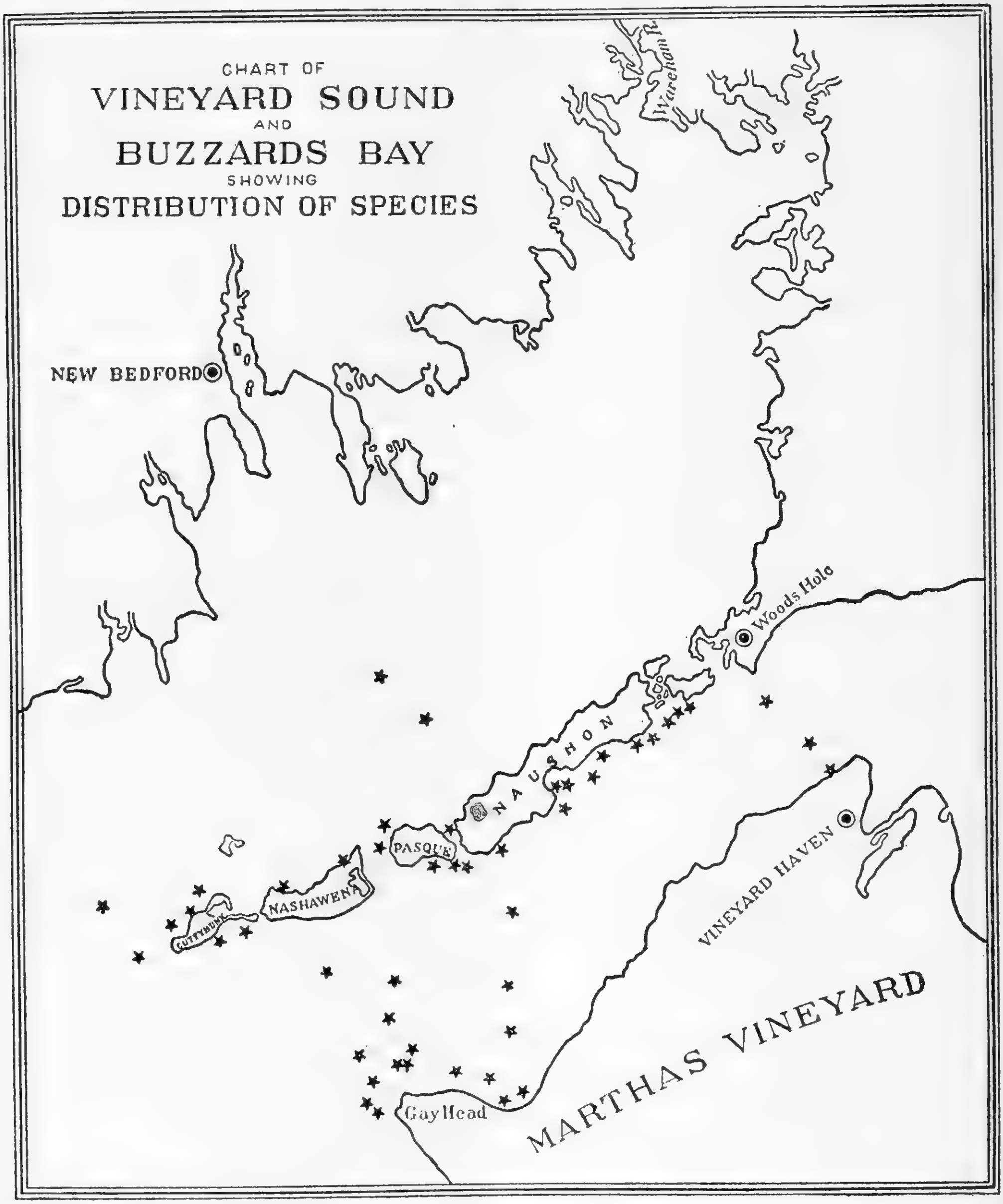

CHART 232.—Desmarestia viridis (Flora Danica) Lamouroux.

Presents a much more extended range than *Desmarestia aculeata* (chart 231), being found in warmer regions of Vineyard Sound as well as in the cooler waters.

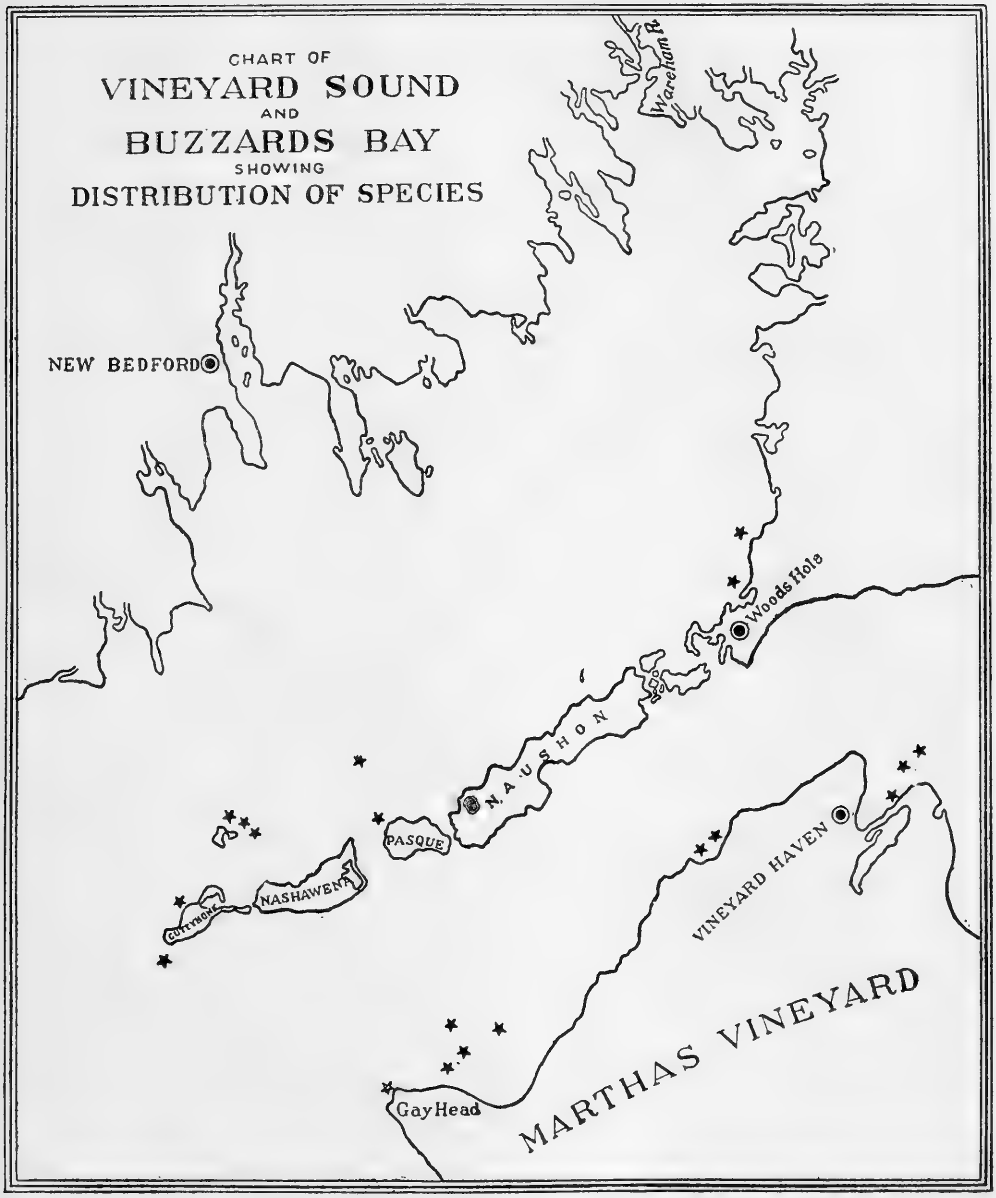

CHART 233.—Dictyosiphon hippuroides (Lyngbye) Areschoug.

A scattered distribution in both Buzzards Bay and Vineyard Sound.

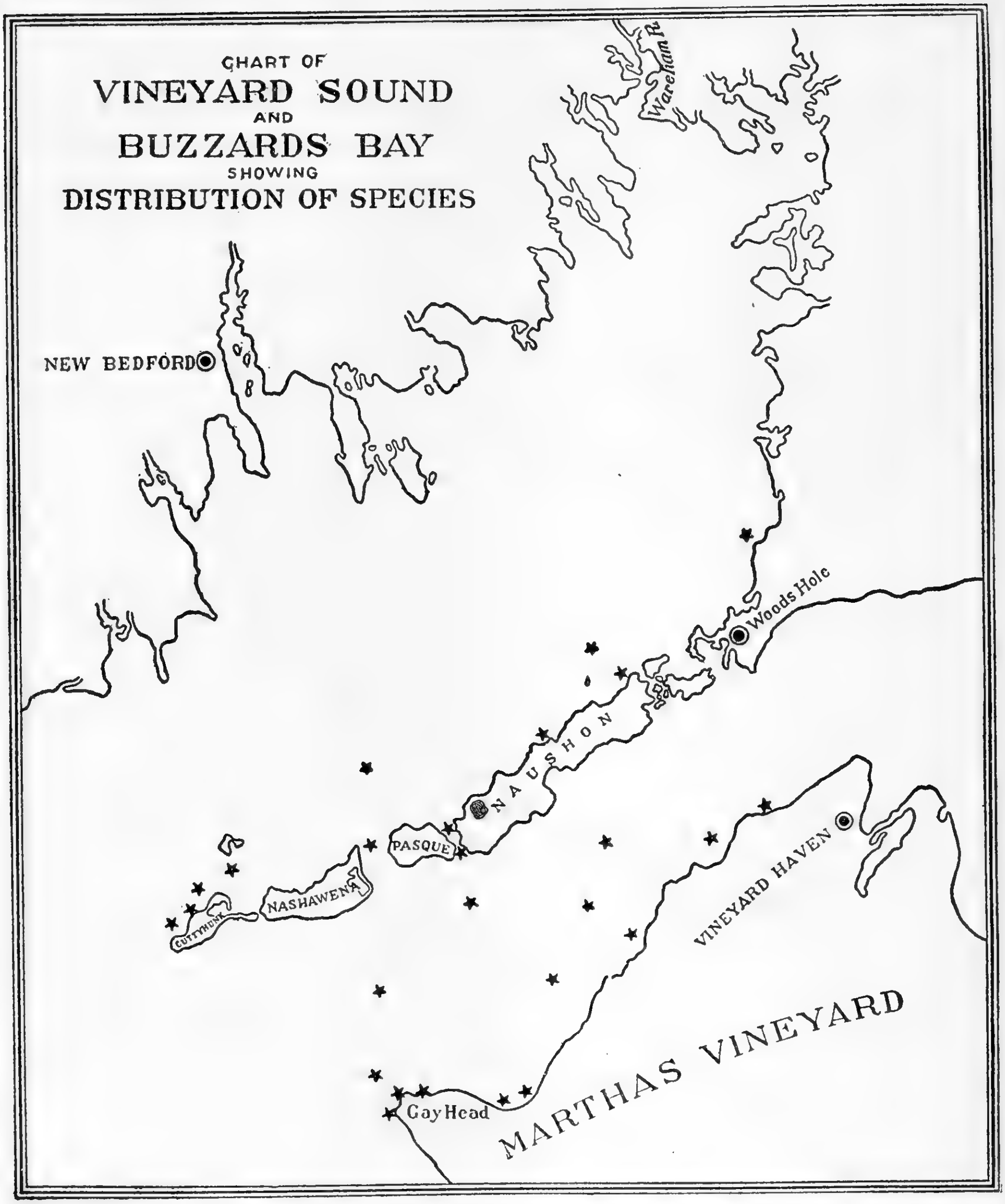

CHART 234.—Chorda filum (Linnæus) Stackhouse.

This species, very common in quiet shallow waters, is also widely distributed in the deeper waters of both Buzzards Bay and Vineyard Sound.

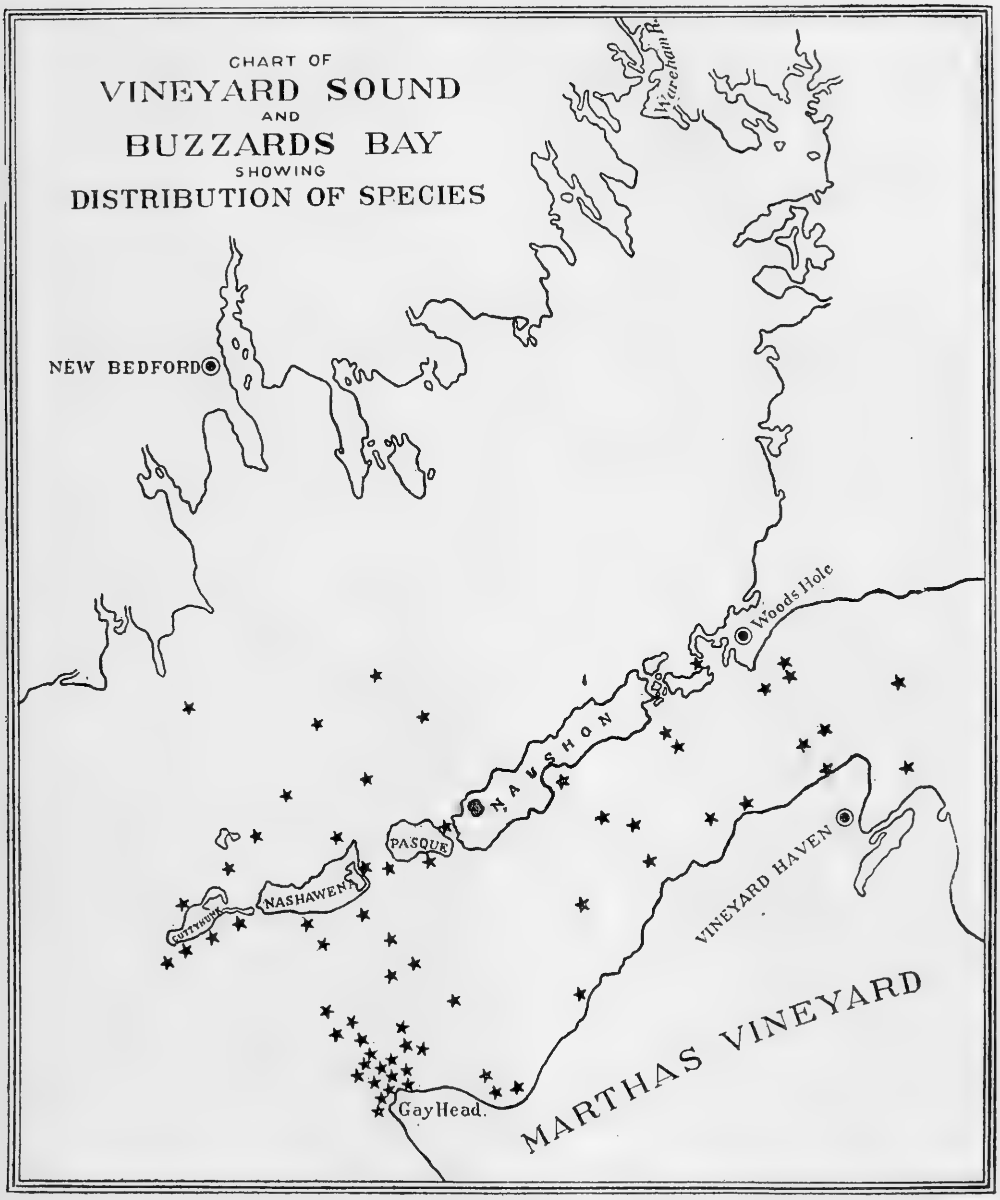

CHART 235.—Laminaria Agardhii Kjellman.

Widely distributed in the lower portion of Buzzards Bay and throughout Vineyard Sound, preferring the cooler waters.

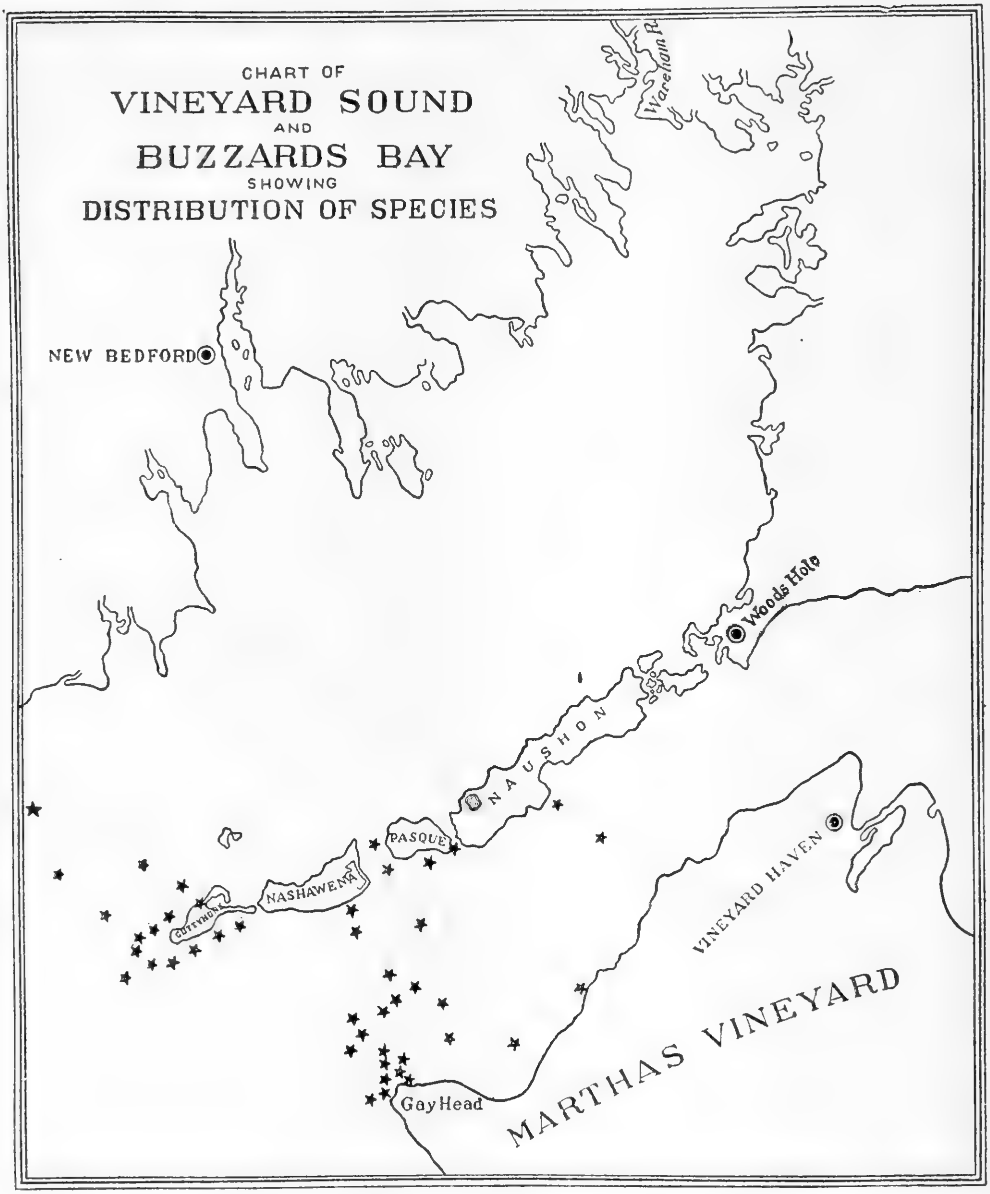

CHART 236.—Laminaria Agardhii, var. vittata Setchell.

This characteristic form of the species (chart 235) is almost restricted to the cooler waters of the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound.

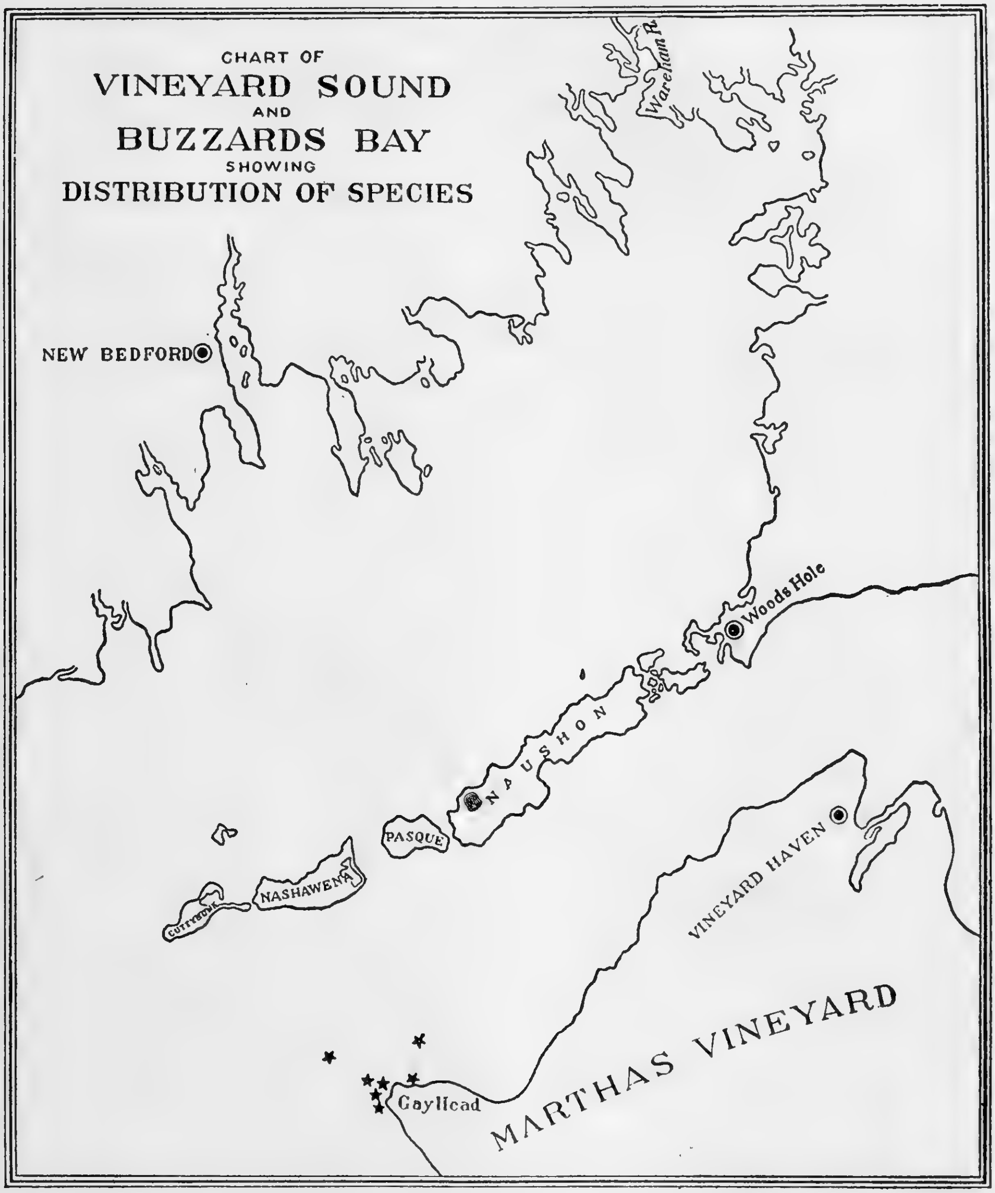

CHART 237.—Laminaria digitata (Linnæus) Lamouroux.

Local distribution limited to the cooler waters off exposed points, as at Gay Head.

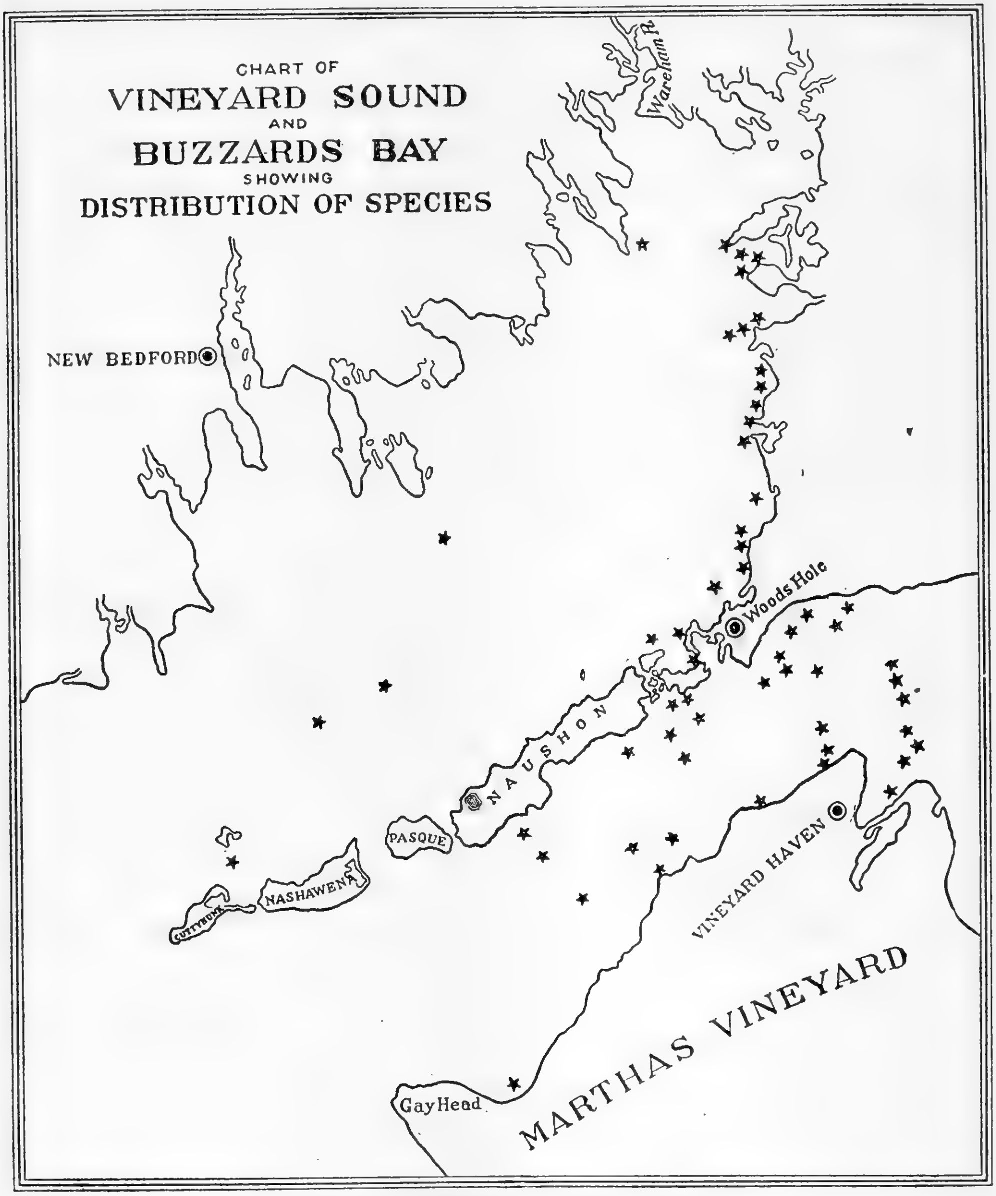

CHART 238.—Sargassum Filipendula Agardh.

Abundant and almost restricted to the warmer and more sheltered regions of Buzzards Bay and Vineyard Sound.

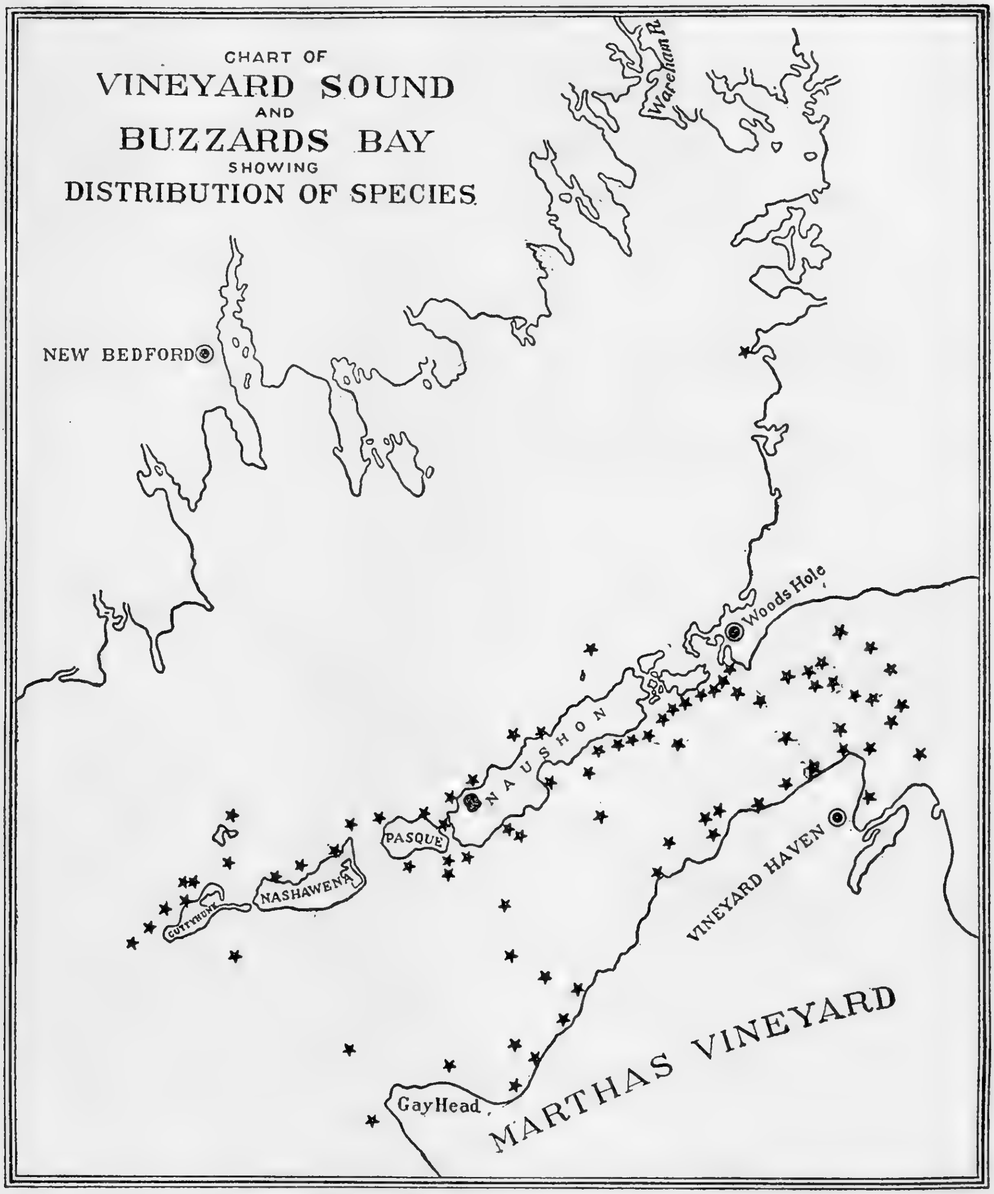

CHART 239.—Antithamnion cruciatum (Agardh) Nägeli.

Widely distributed in both Buzzards Bay and Vineyard Sound over stony bottoms that support extensive growths of *Chondrus*, *Phyllophora*, and *Polyides*, upon which it is a common epiphyte.

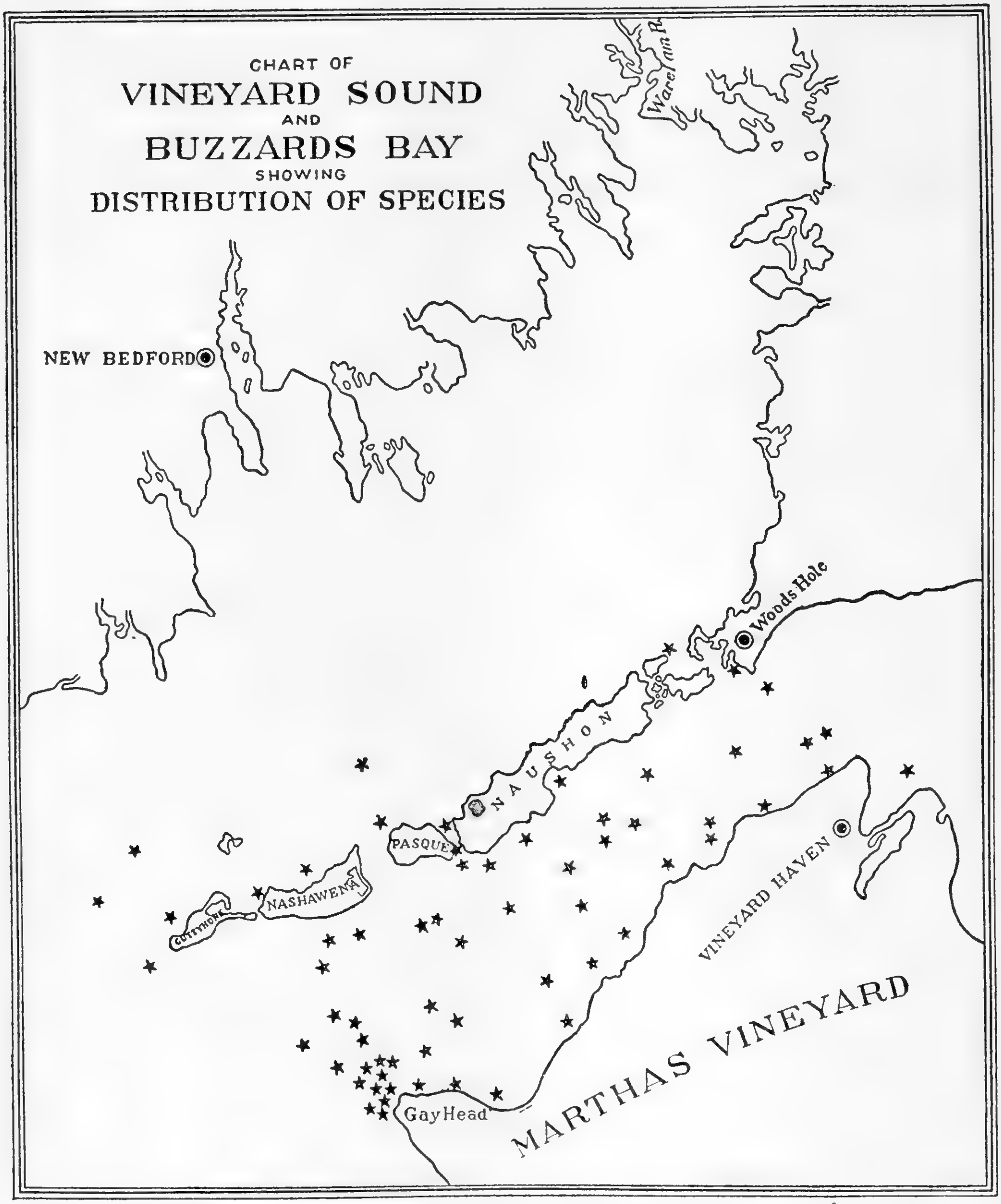

CHART 240.—Ceramium rubrum (Hudson) Agardh.

This very common species of the shallow sublittoral zone is also abundant and widely distributed in the deeper waters.

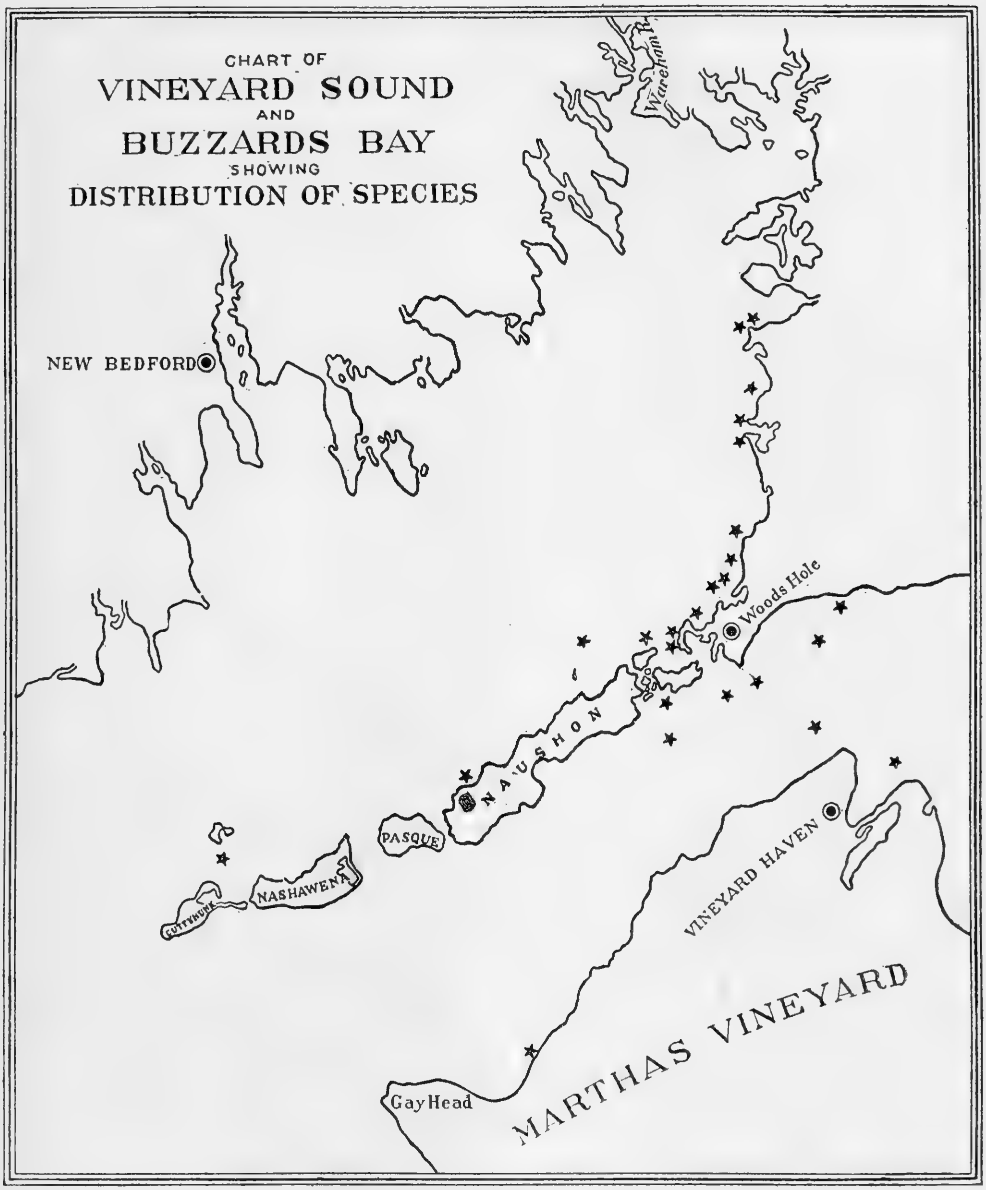

CHART 241.—Griffithsia Bornetiana Farlow.

Local distribution almost restricted to the warmer waters of Buzzards Bay and Vineyard Sound.

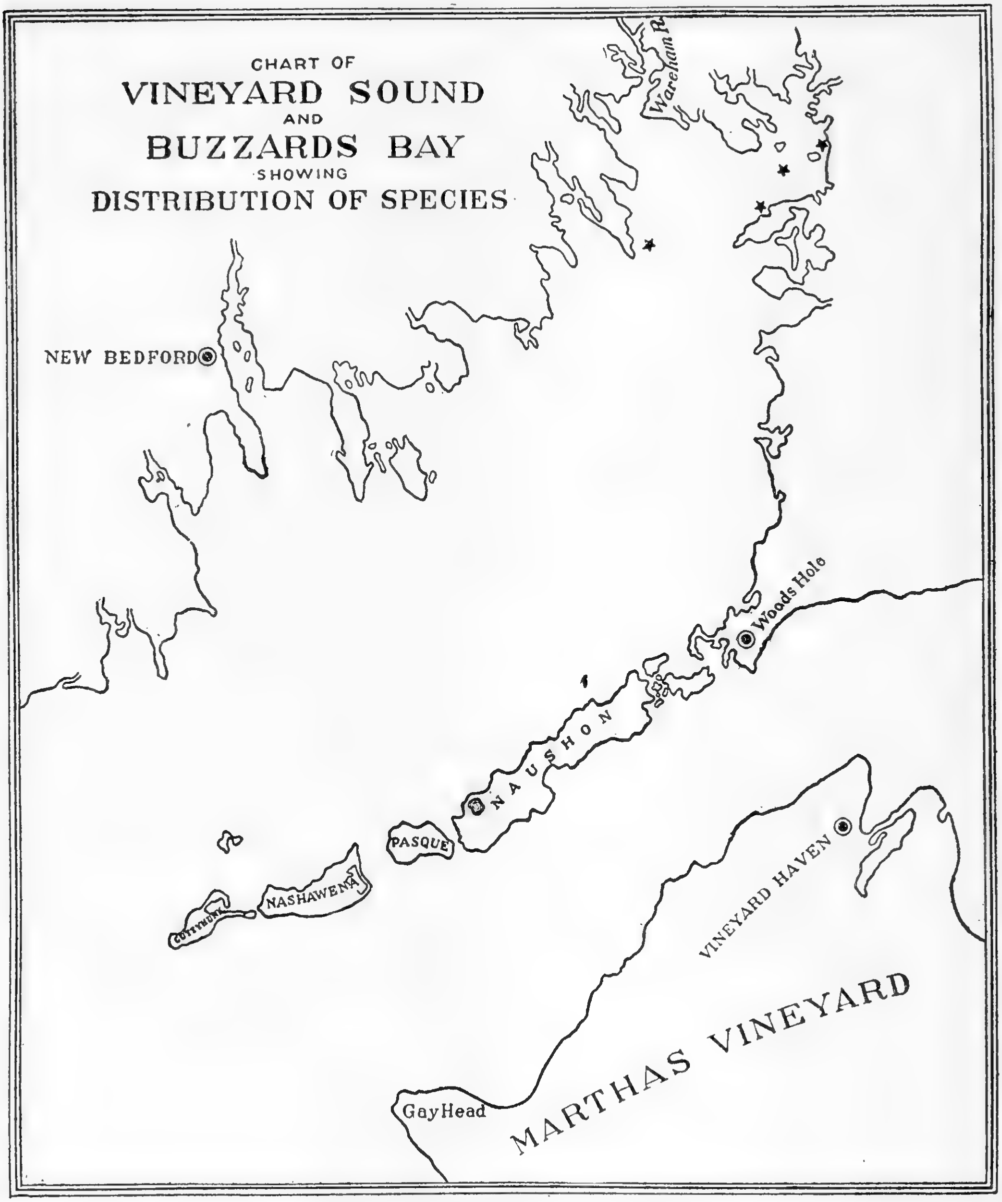

CHART 242.—Griffithsia tenuis Agardh.

Only found in the warm and sheltered portions of Buzzards Bay, where it forms large patches loosely attached over sandy and muddy bottoms.

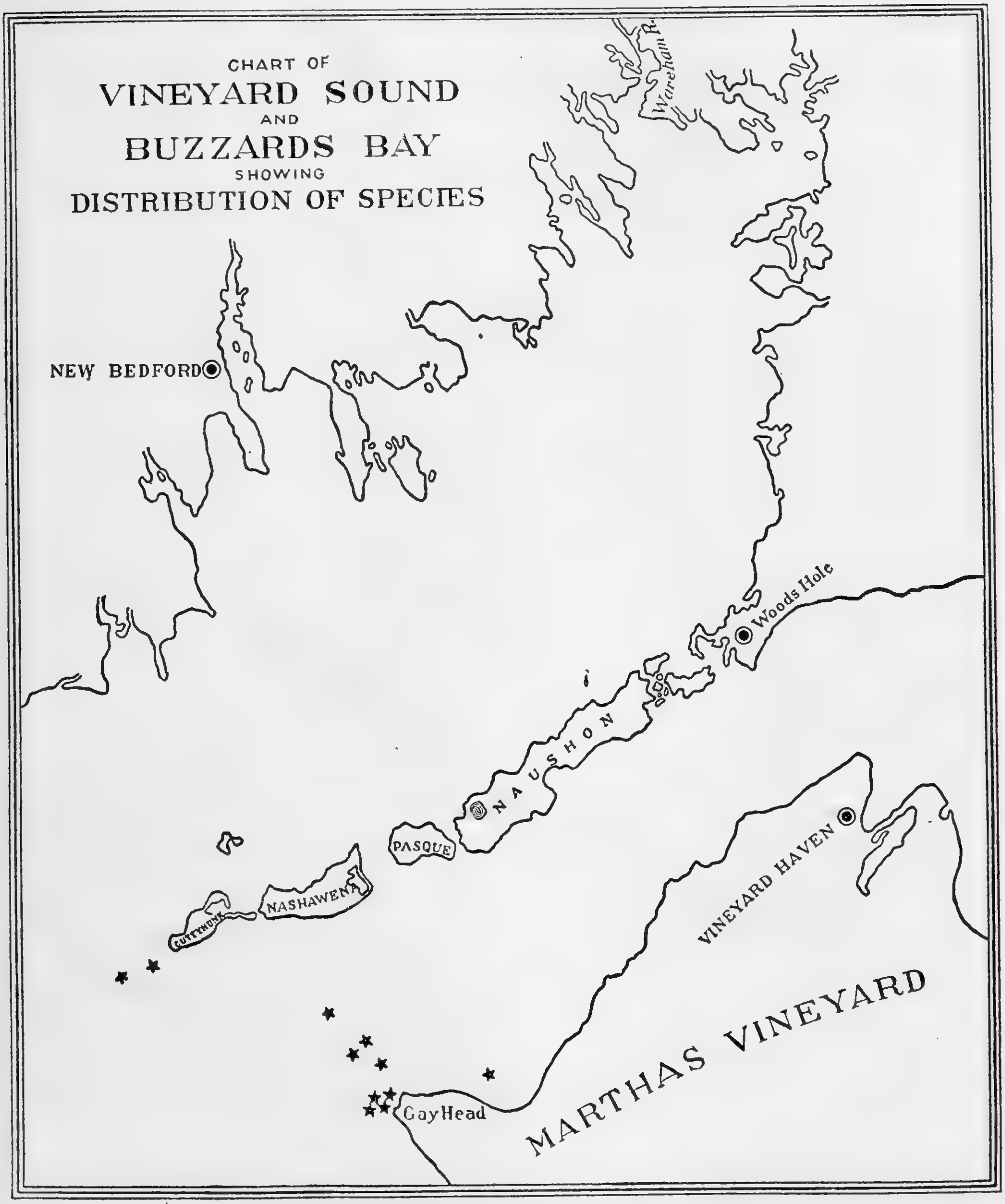

CHART 243.—Plumaria elegans (Bonnemaison) Schmitz.

Local distribution limited to the cooler waters off exposed points, as at Gay Head and Cuttyhunk.

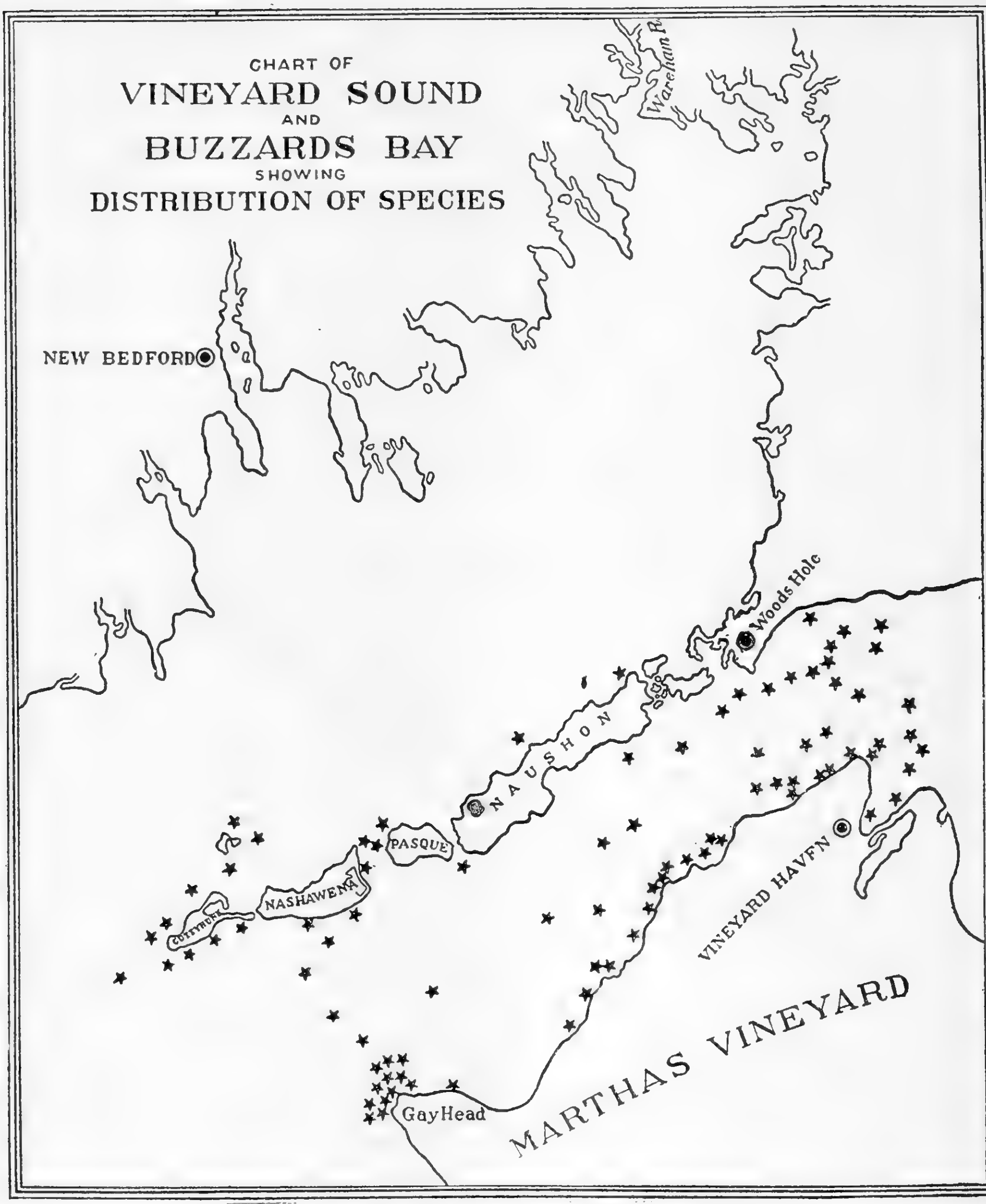

CHART 244.—Spermothamnion Turneri (Mertens) Areschoug.

This striking epiphyte is widely distributed in both Buzzards Bay and Vineyard Sound over bottoms that support growths of *Chondrus*, *Phyllophora*, and *Polyides*.

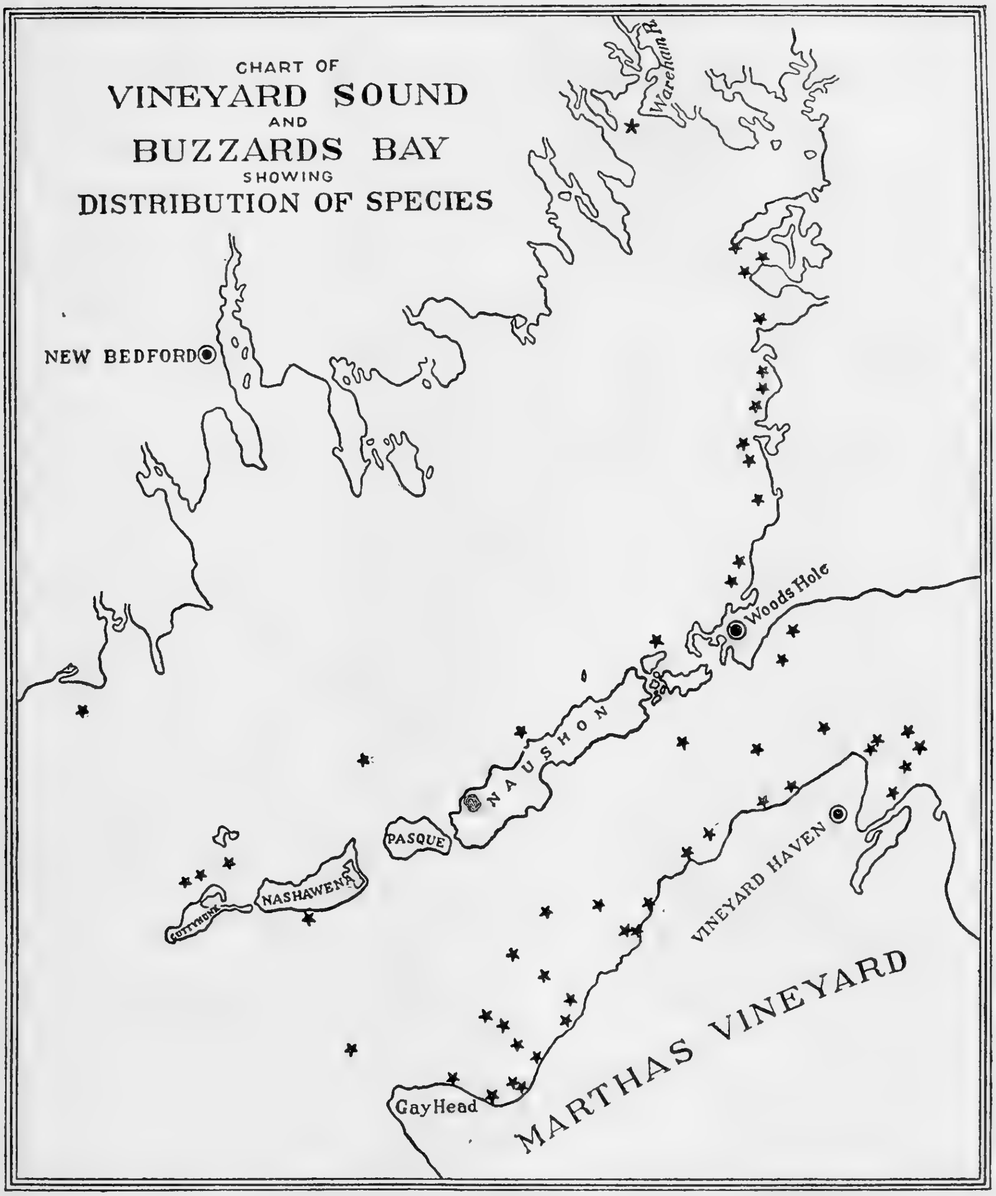

CHART 245.—Spyridia filamentosa (Wulfen) Harvey.

Widely distributed in both Buzzards Bay and Vineyard Sound, but preferring the warmer waters of the more sheltered portions.

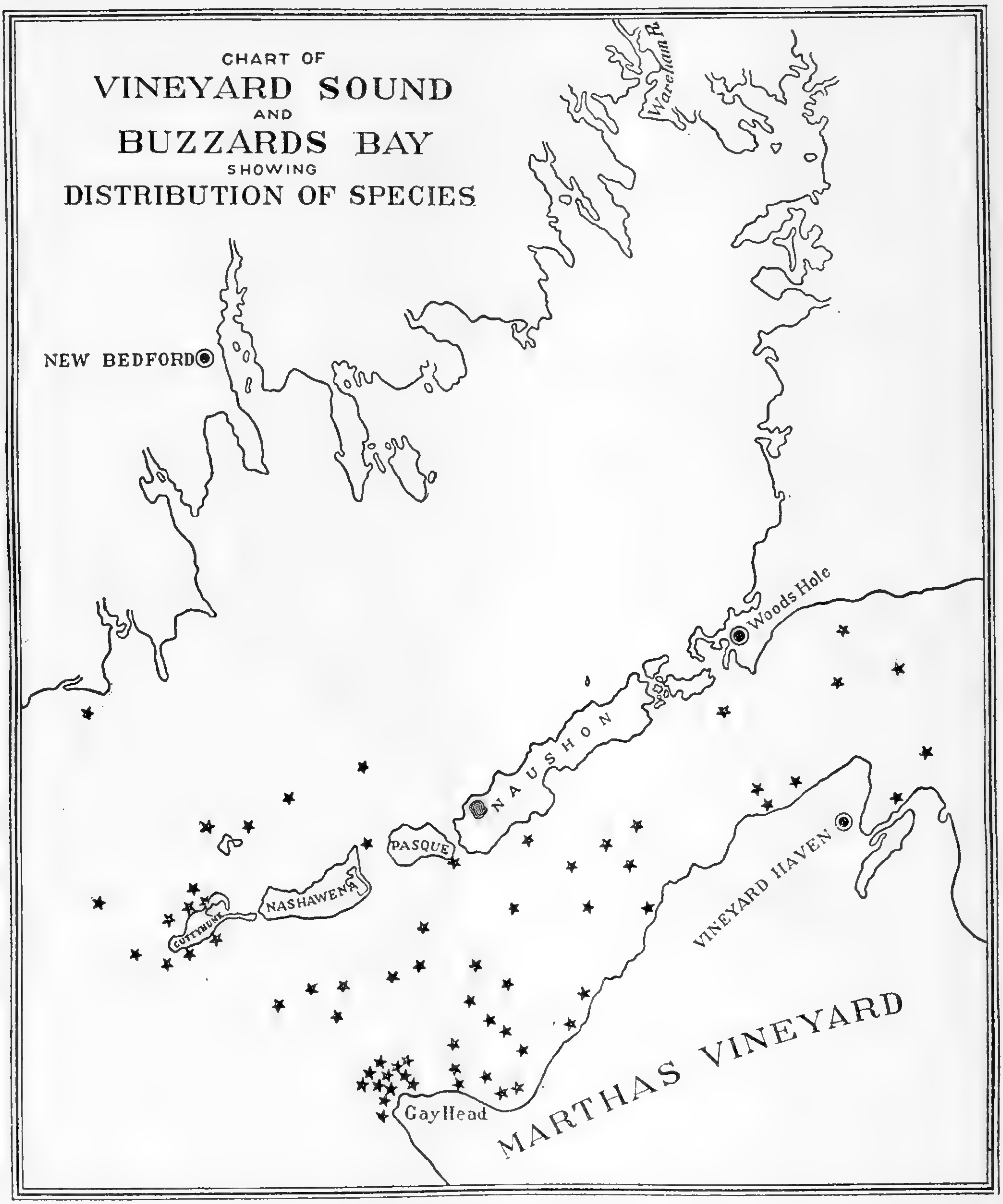

CHART 246.—Polysiphonia elongata (Hudson) Harvey.

Prefers the cooler waters of the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound, but presents a somewhat scattered distribution.

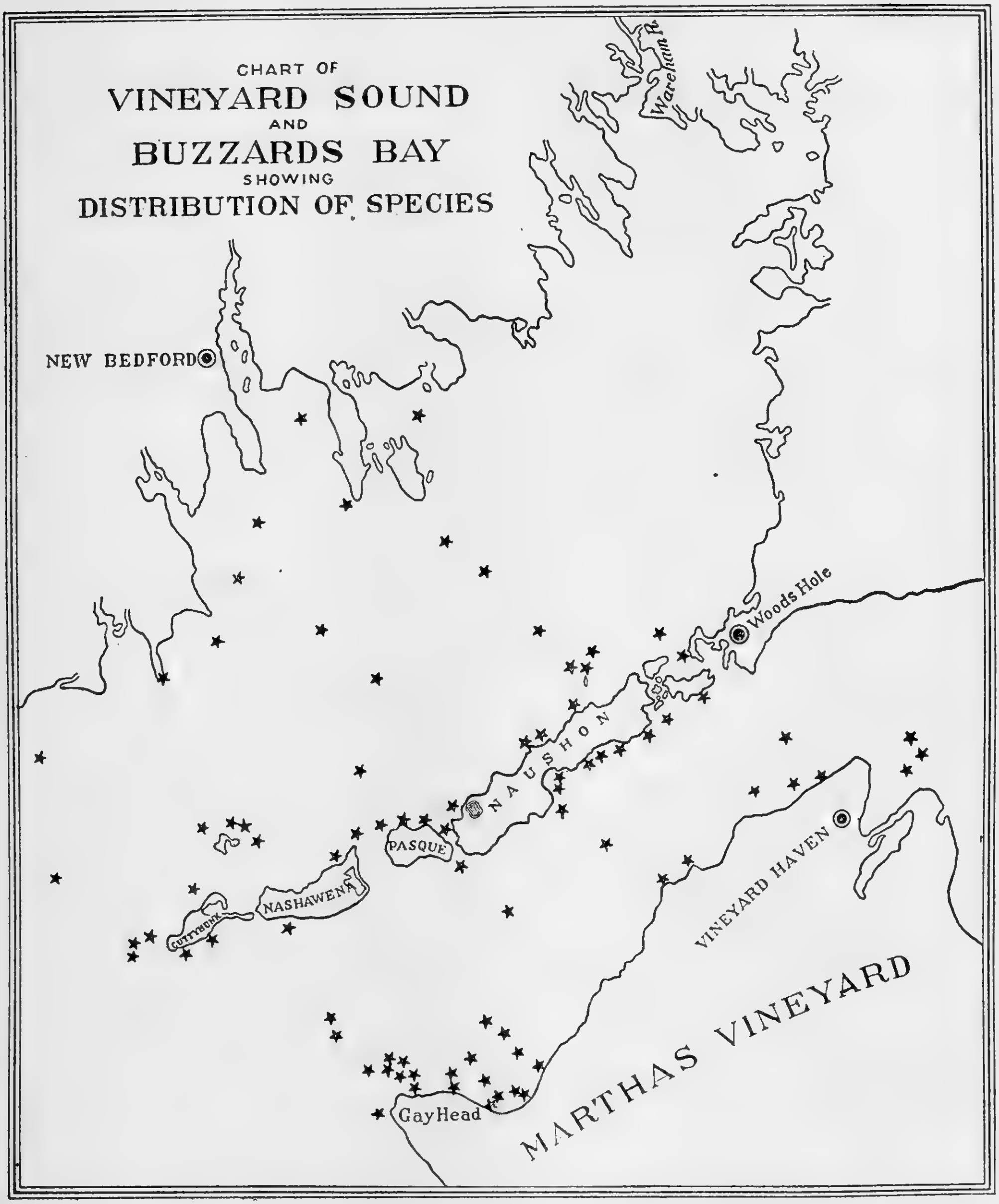

CHART 247.—Polysiphonia nigrescens (Dillwyn) Greville.

A species abundant and widely distributed, growing on stones and shells frequently over muddy bottoms, which accounts for its presence in the middle regions of Buzzards Bay.

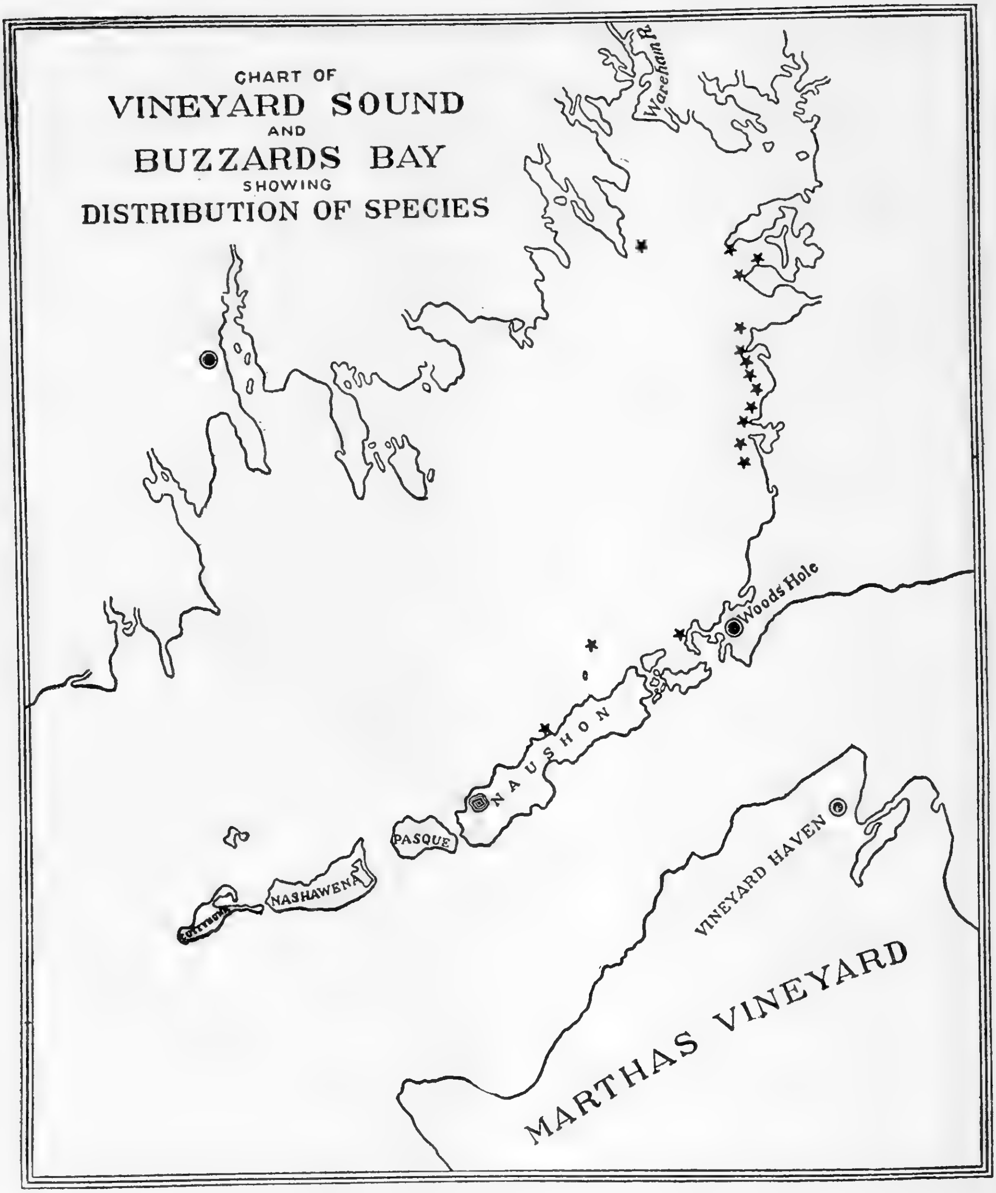

CHART 248.—Polysiphonia variegata (Agardh) Zanardini.

Restricted to the warmer waters of sheltered regions and only dredged by the Survey in Buzzards Bay.

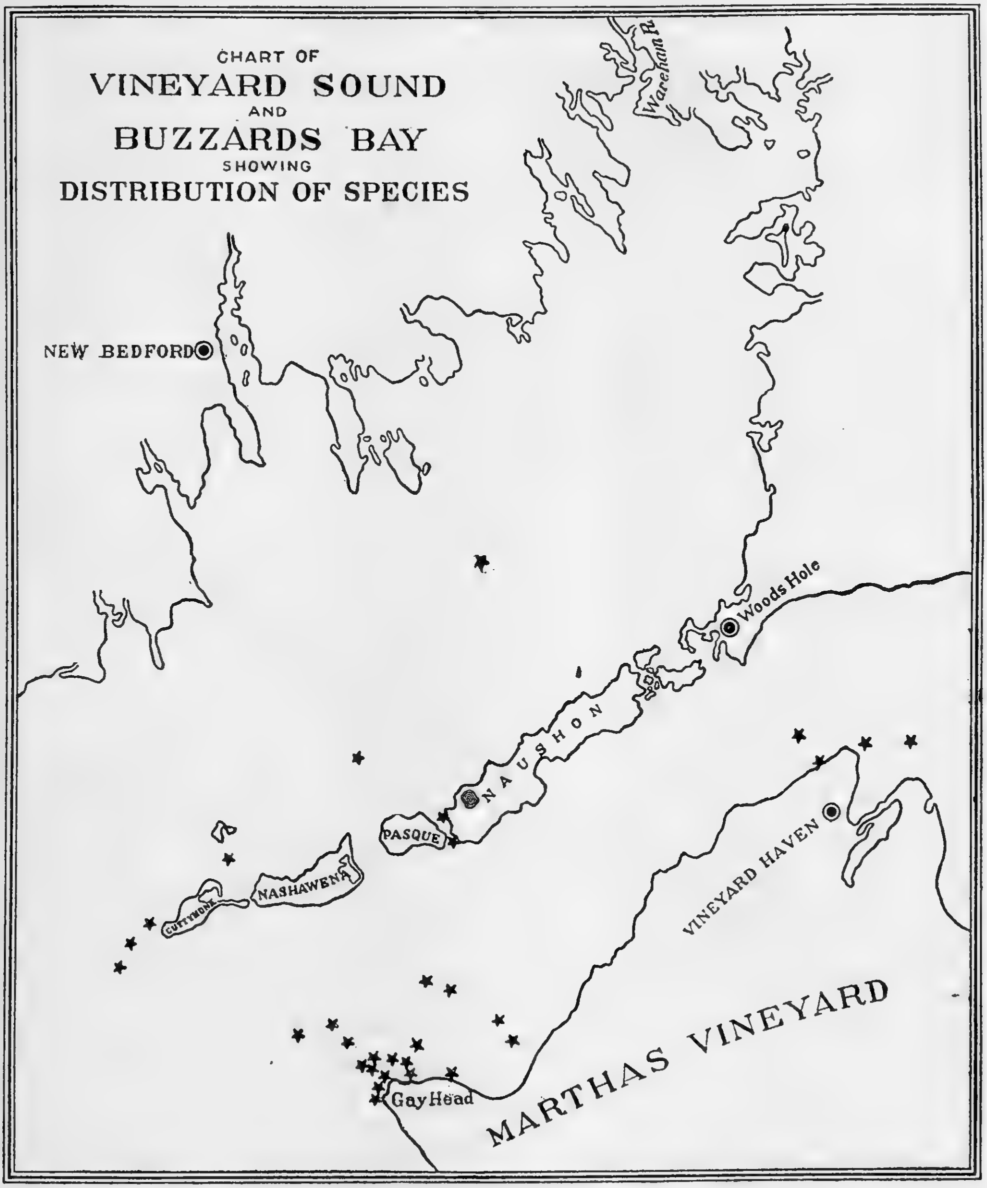

CHART 249.—Ahnfeldtia plicata (Turner) Fries.

Prefers the cooler waters off exposed points.

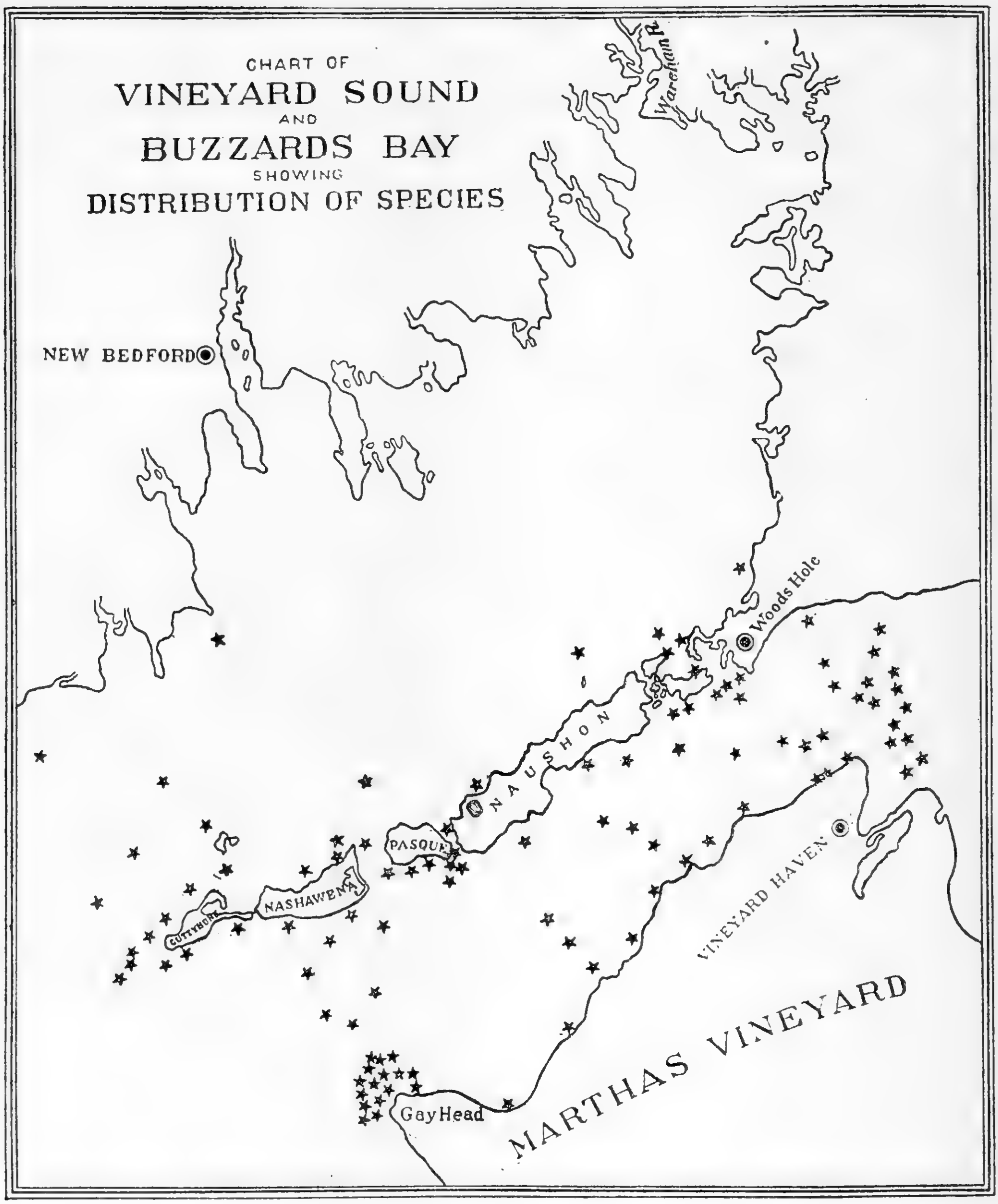

CHART 250.—Chondrus crispus (Linnæus) Stackhouse.

Widely distributed over sandy, shelly, and stony bottoms.

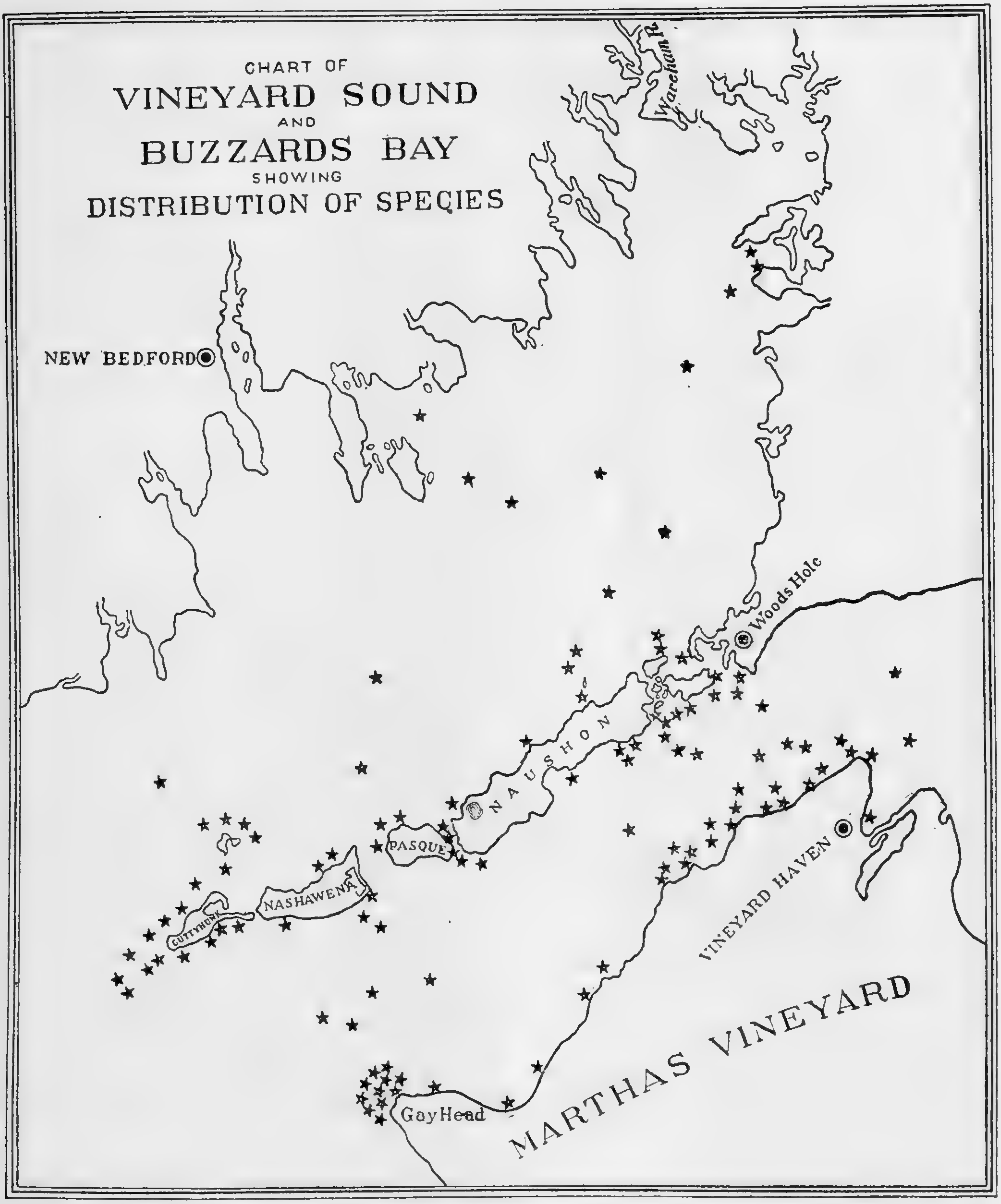

CHART 251.—Phyllophora Brodiæi (Turner) J. Agardh.

Very generally distributed throughout Buzzards Bay and Vineyard Sound but most abundant in exposed situations.

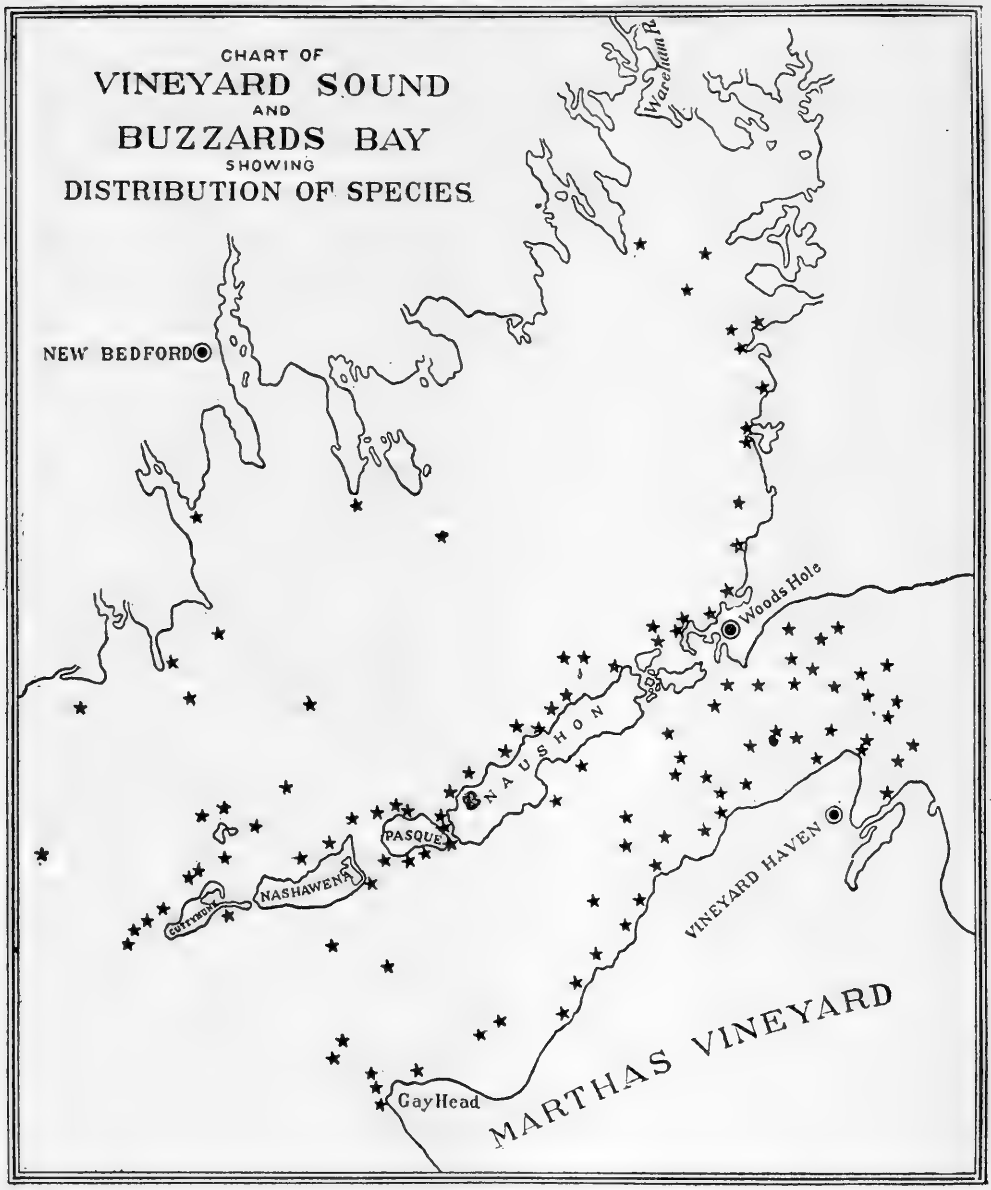

CHART 252.—Phyllophora membranifolia (Goodenough & Woodward) J. Agardh.

As widely distributed as *Phyllophora Brodiæi* (chart 251) but apparently showing a preference for more sheltered regions.

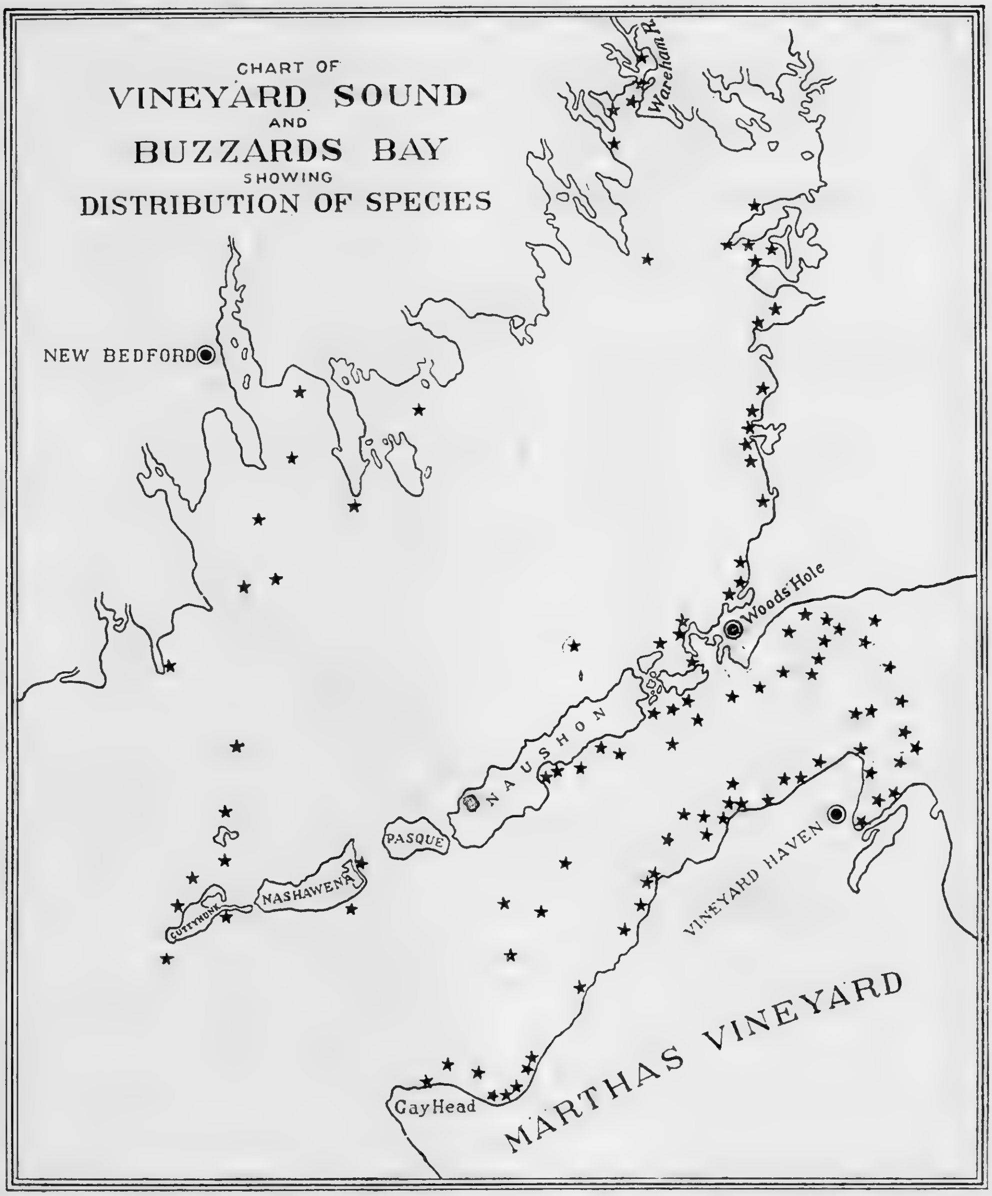

CHART 253.—Agardhiella tenera (J. Agardh) Schmitz.

A very common and widely distributed species which, however, prefers warm and sheltered waters.

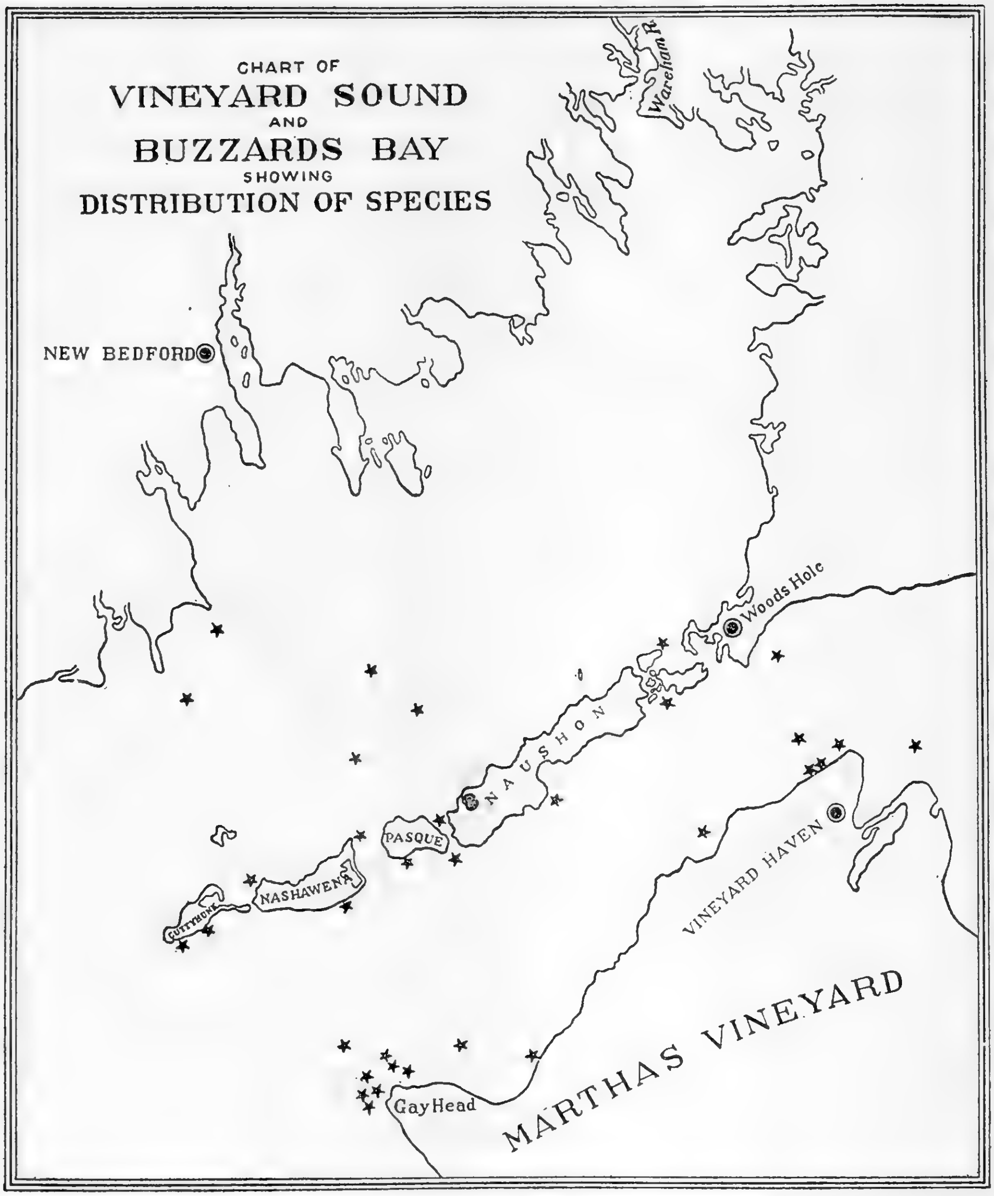

CHART 254.—Cystoclonium purpurascens (Hudson) Kützing.

A scattered distribution in both Buzzards Bay and Vineyard Sound.

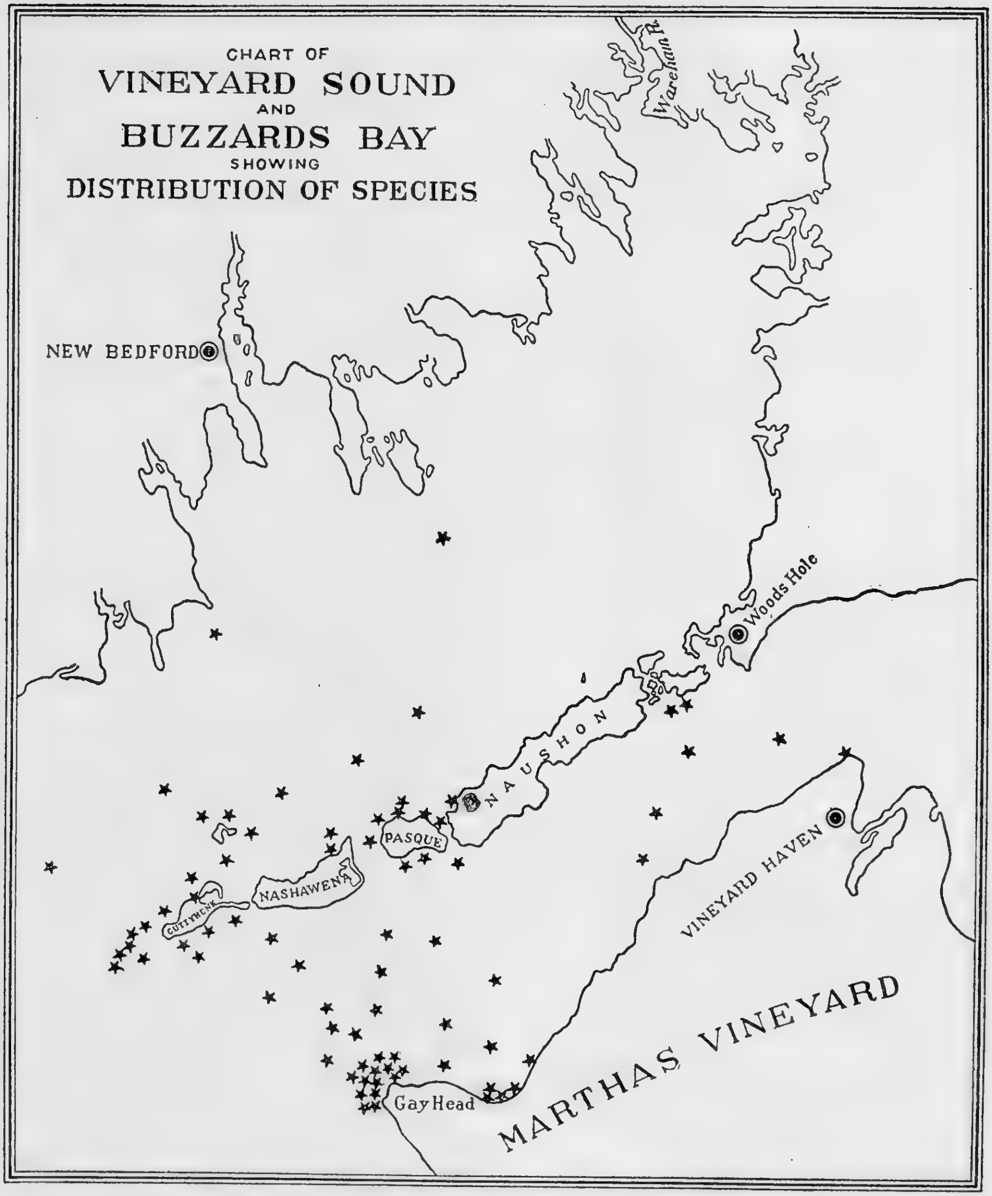

CHART 255.—Cystoclonium purpurascens var. cirrhosum Harvey.

This form of the species (chart 254) shows a marked preference for the cooler waters of the lower portion of Buzzards Bay and the westerly portion of Vineyard Sound.

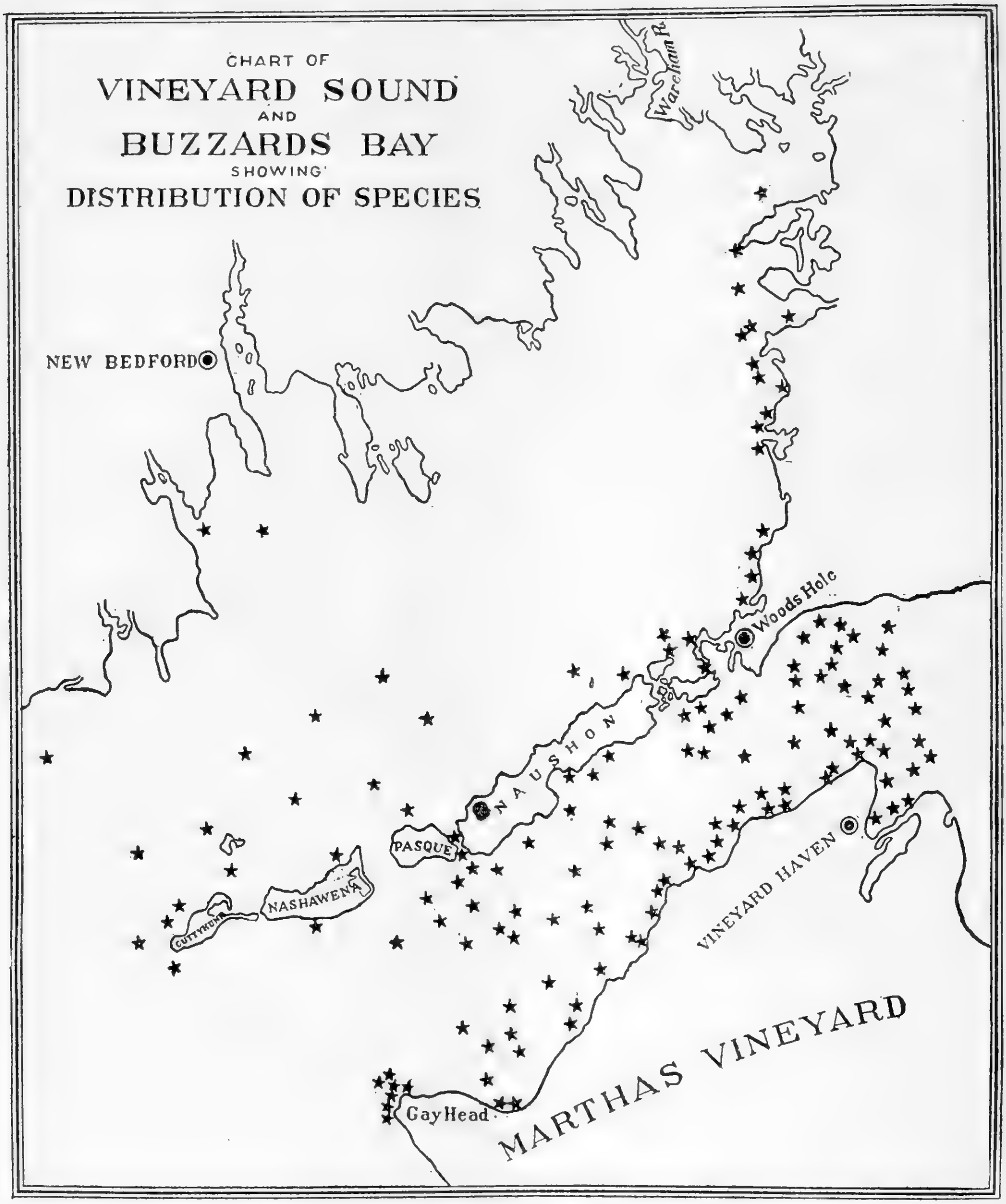

CHART 256.—Champia parvula (Agardh) Harvey.

One of the most widely distributed algæ of the region but preferring warmer and sheltered waters.

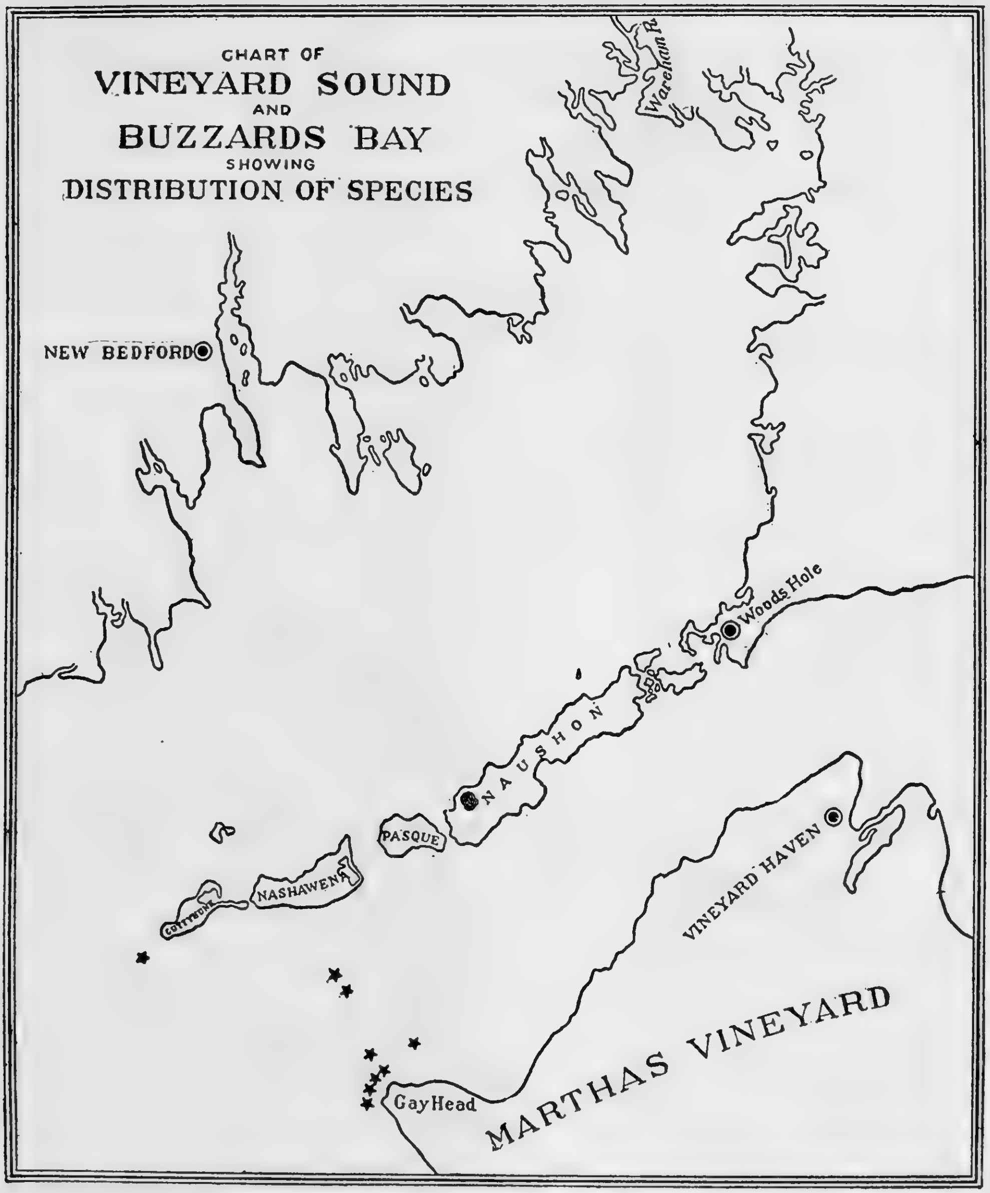

CHART 257.—Lomentaria rosea (Harvey) Thuret.

Restricted to the cooler waters off the exposed points of Gay Head and Cuttyhunk.

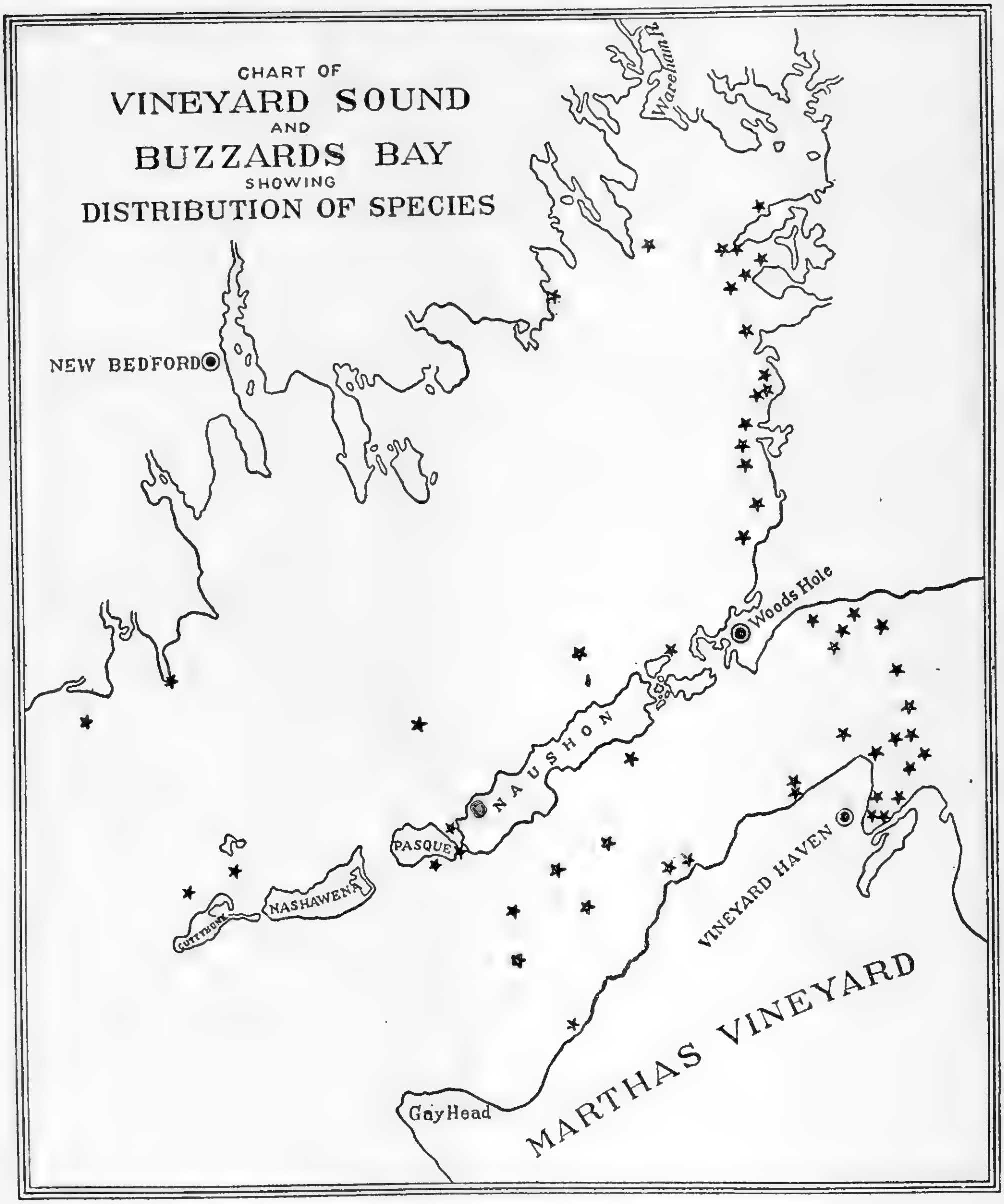

CHART 258.—Lomentaria uncinata Meneghini.

In striking contrast to *Lomentaria rosea* (chart 257) this species is almost restricted to the warmer sheltered waters of Buzzards Bay and Vineyard Sound, where it is widely distributed.

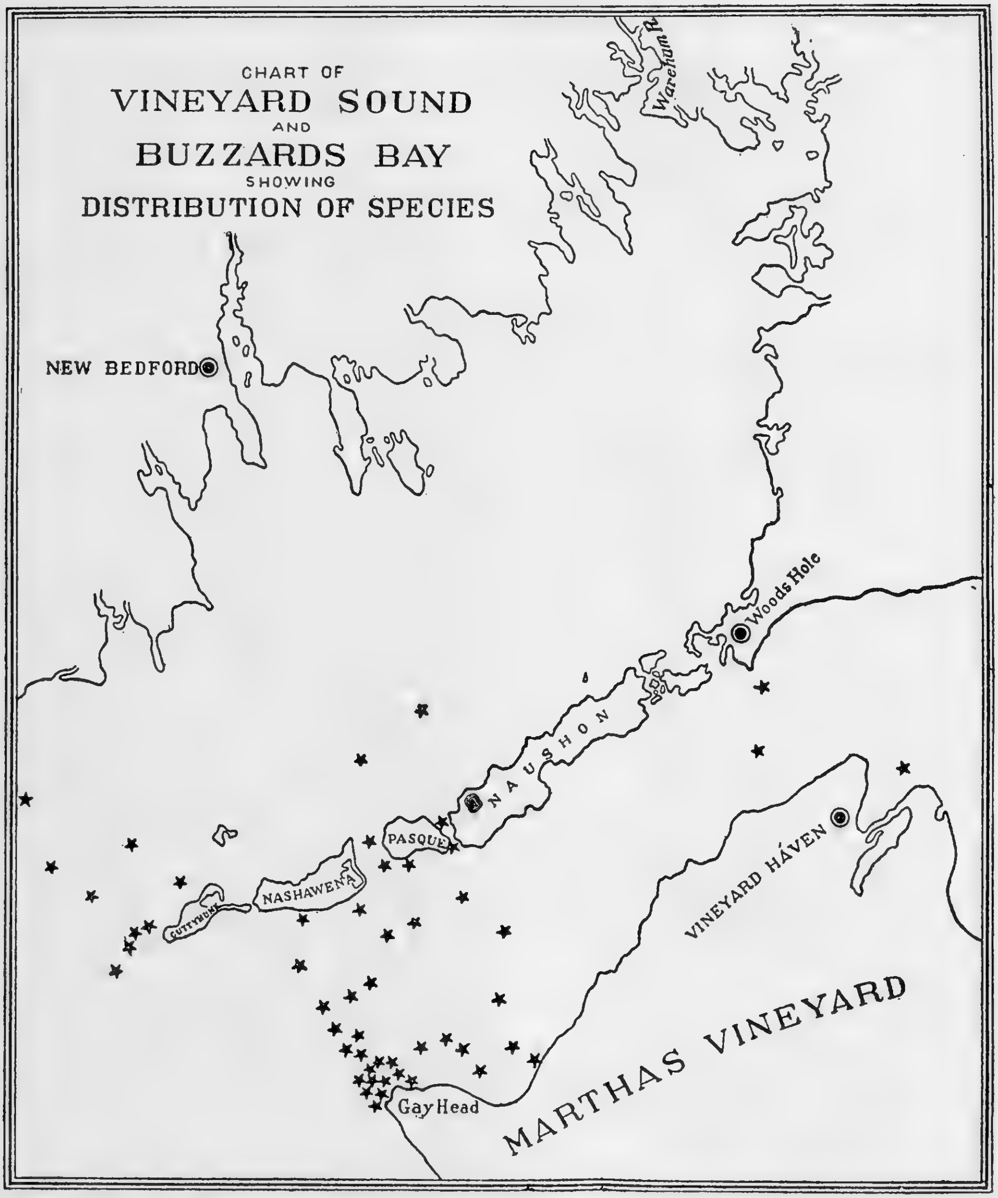

CHART 259.—Rhodymenia palmata (Linnæus) Greville.

A characteristic species of the cooler waters of the lower portion of Buzzards Bay and westerly portion of Vineyard Sound.

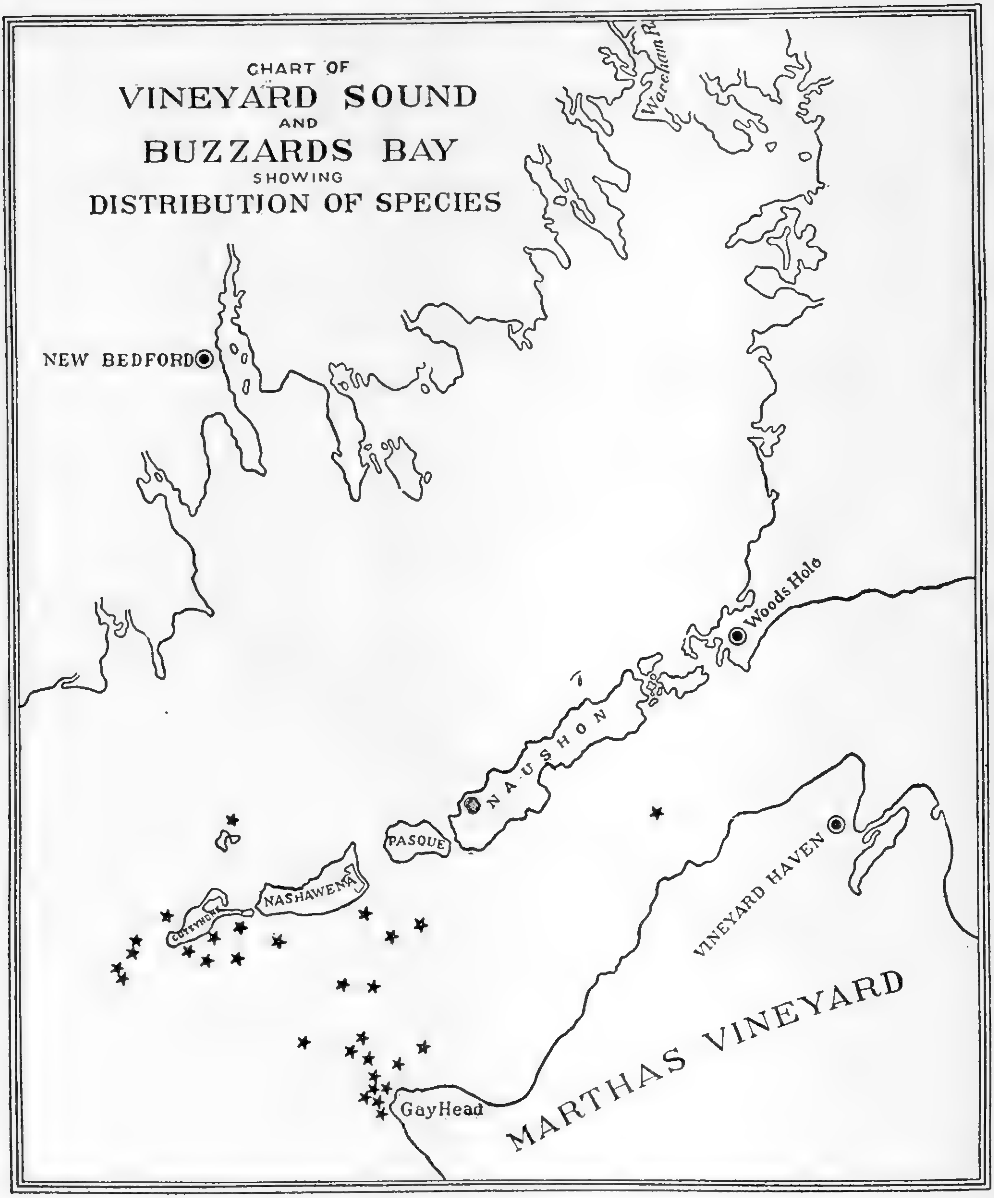

CHART 260.—Delesseria sinuosa (Goodenough & Woodward) Lamouroux.

A striking species practically restricted to the lower portion of Buzzards Bay and westerly portion of Vineyard Sound.

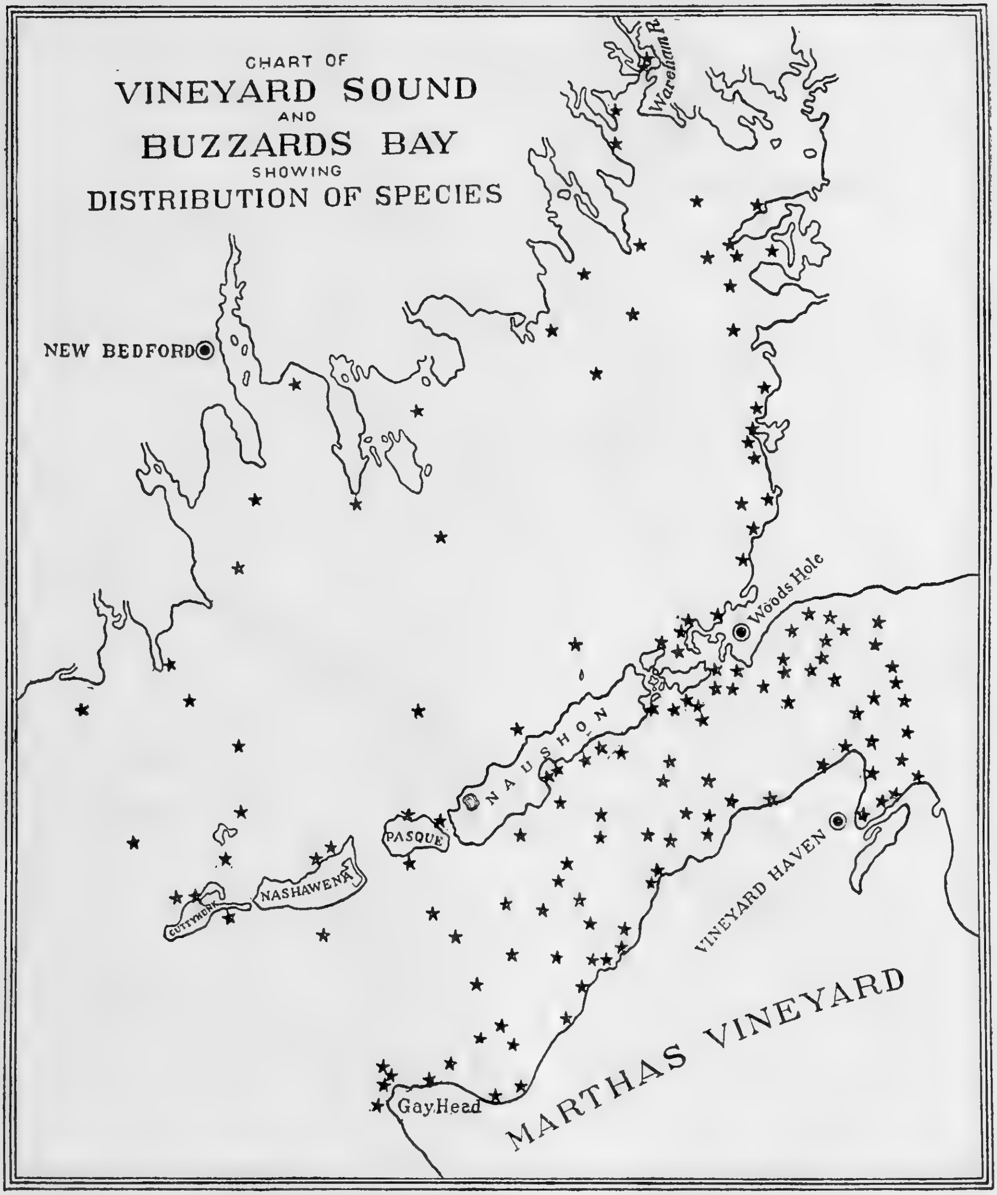

CHART 261.—Grinnellia americana (Agardh) Harvey.

This species is almost universally distributed throughout Buzzards Bay and Vineyard Sound, but prefers the warmer and more sheltered waters.

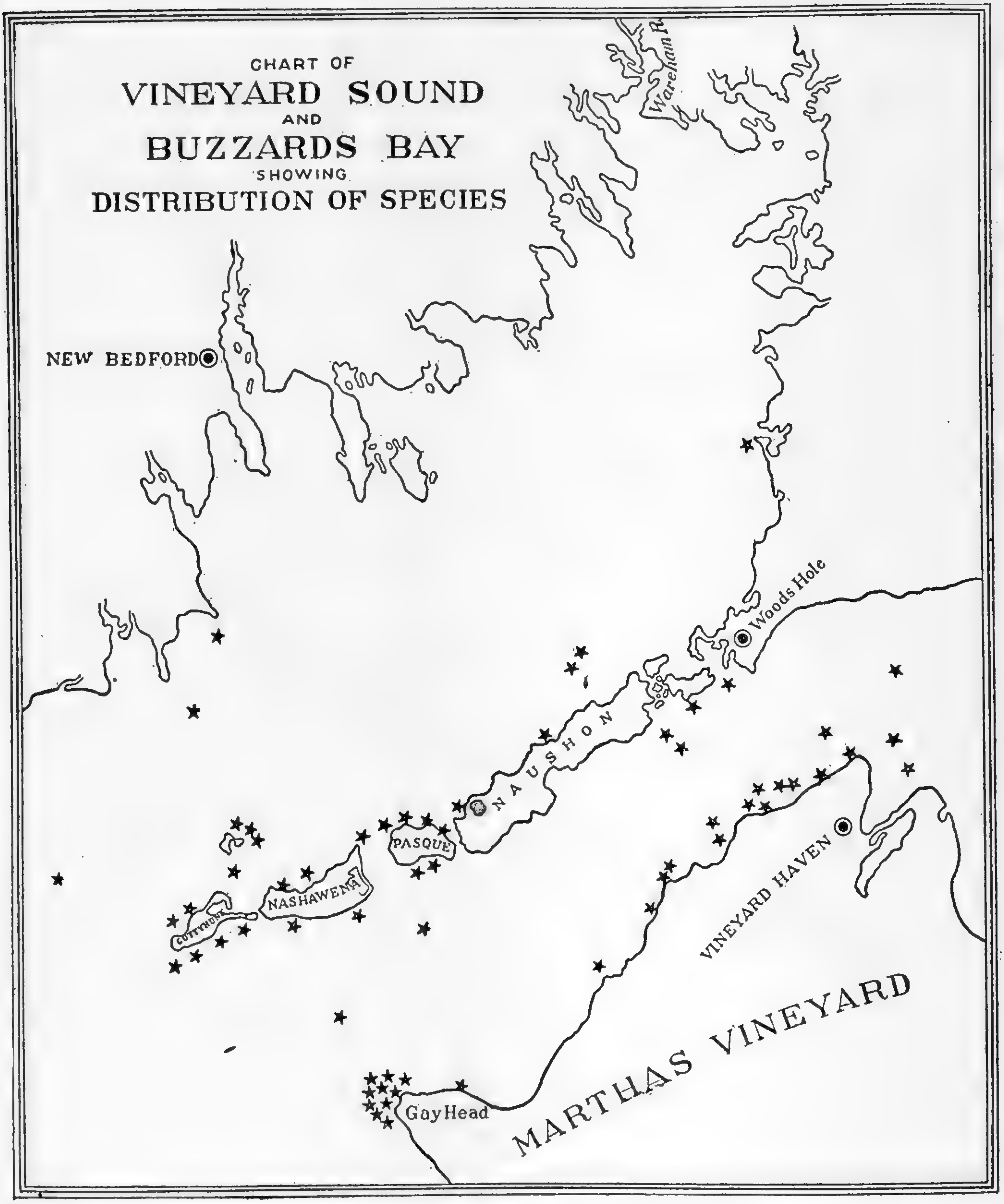

CHART 262.—Polyides rotundus (Gmelin) Greville.

Presents a scattered distribution in Buzzards Bay and Vineyard Sound over sandy, shelly, and stony bottoms.

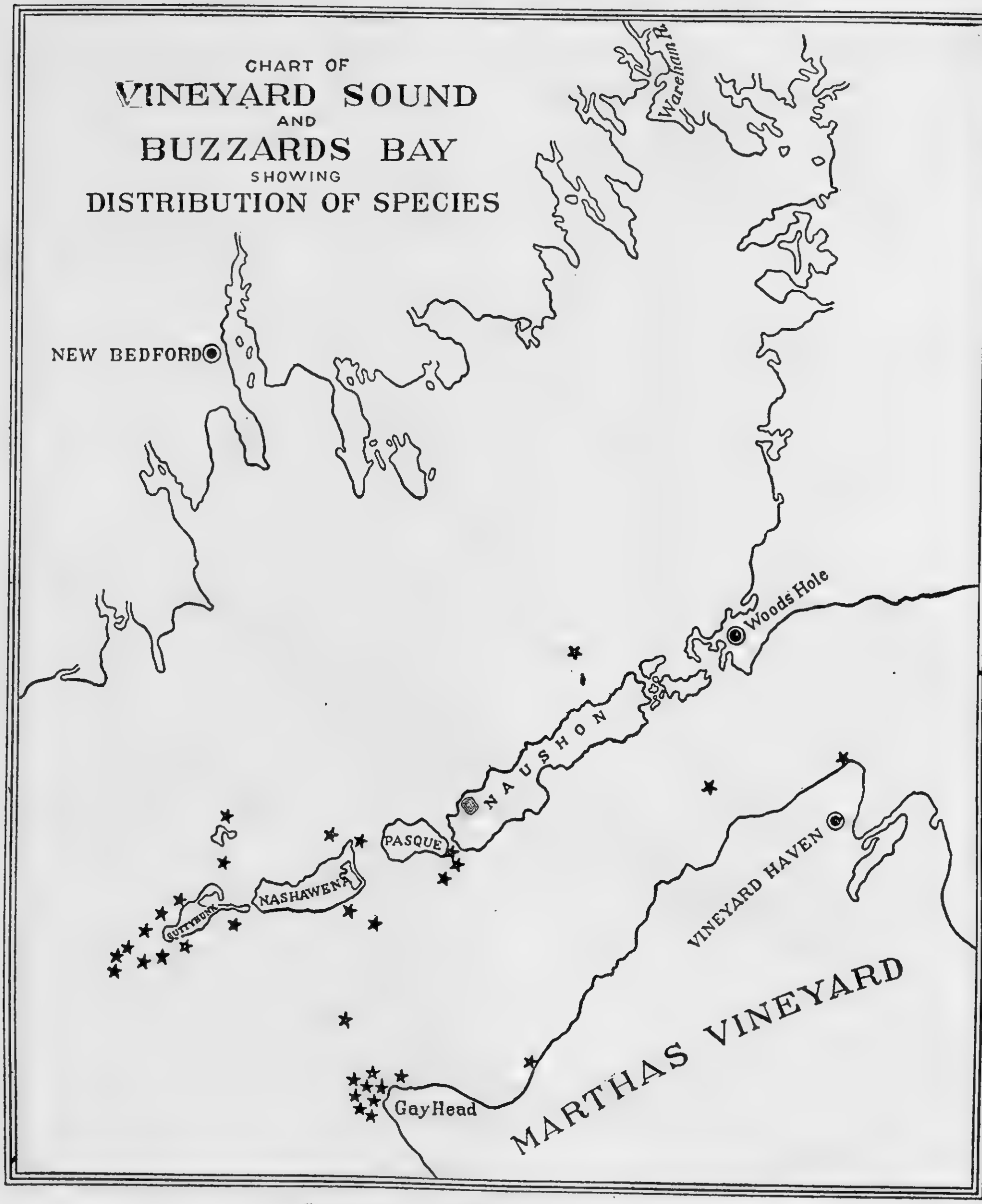

CHART 263.—Corallina officinalis Linnæus.

As dredged by the Survey the species shows a marked preference for the cooler waters off exposed points, as at Gay Head and Cuttyhunk.

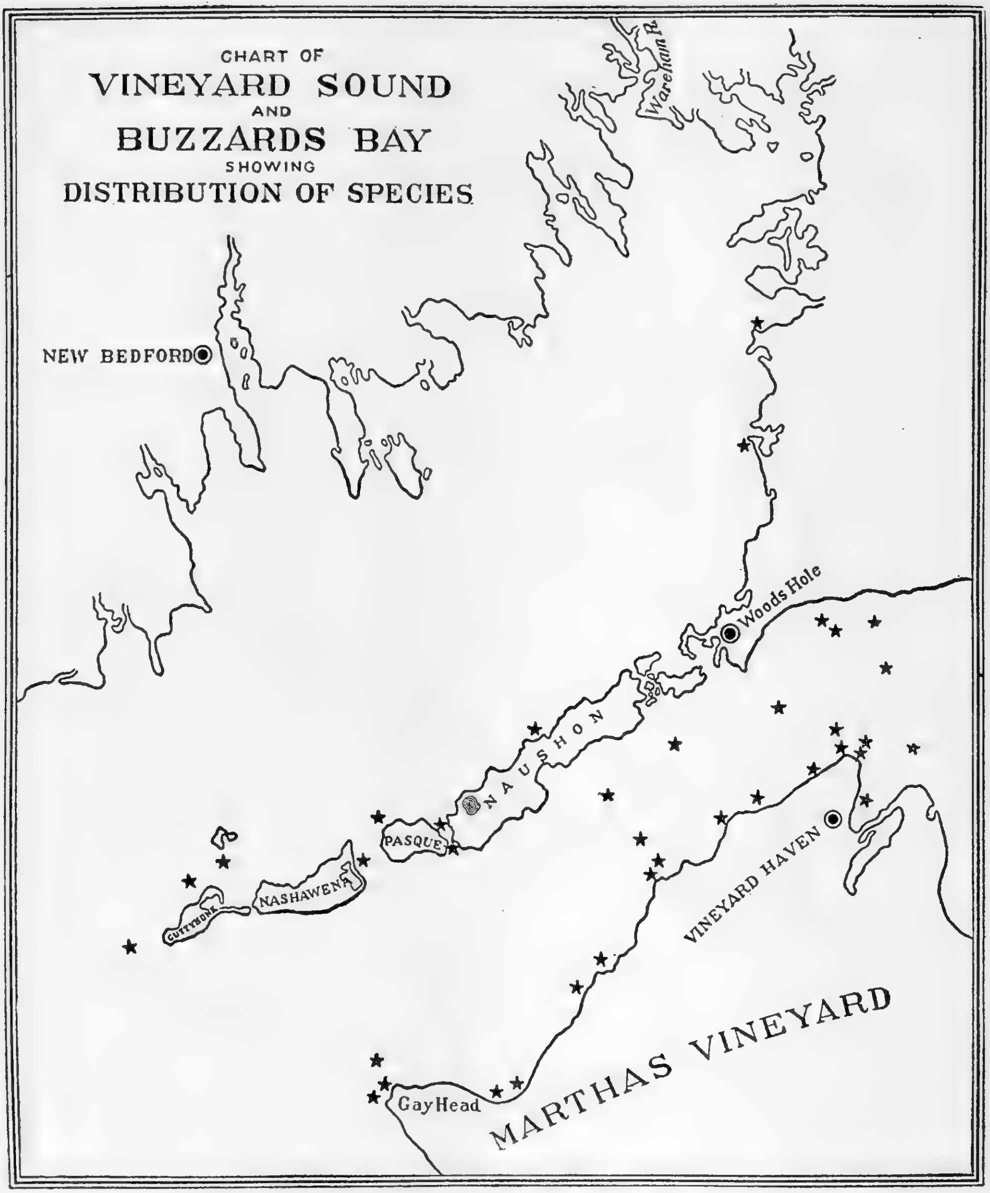

CHART 264.—Hildenbrandia prototypus Nardo.

A scattered distribution in both Buzzards Bay and Vineyard Sound.

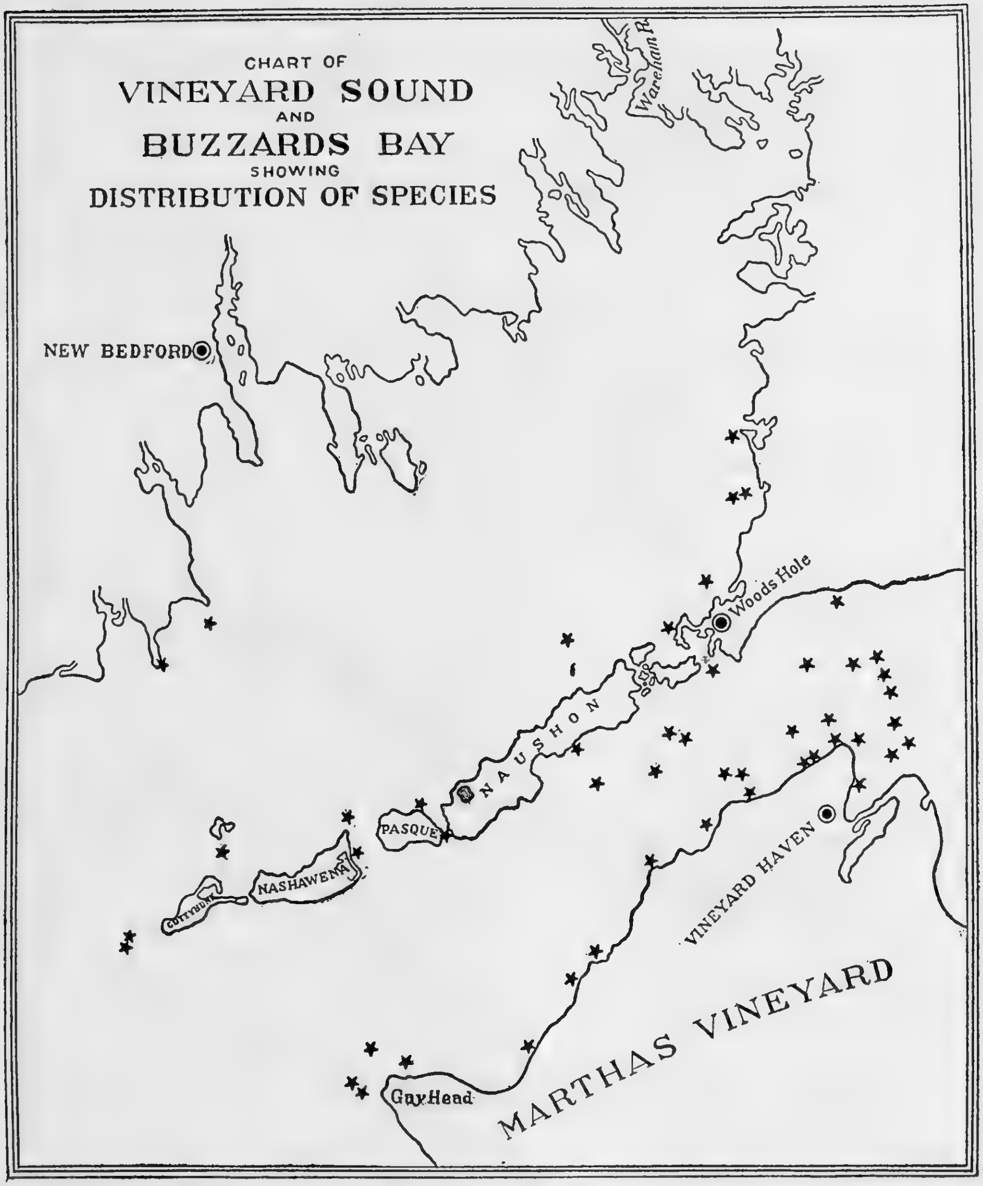

CHART 265.—Lithothamnion polymorphum (Linnæus) Areschoug.

Widely distributed in both Buzzards Bay and Vineyard Sound.

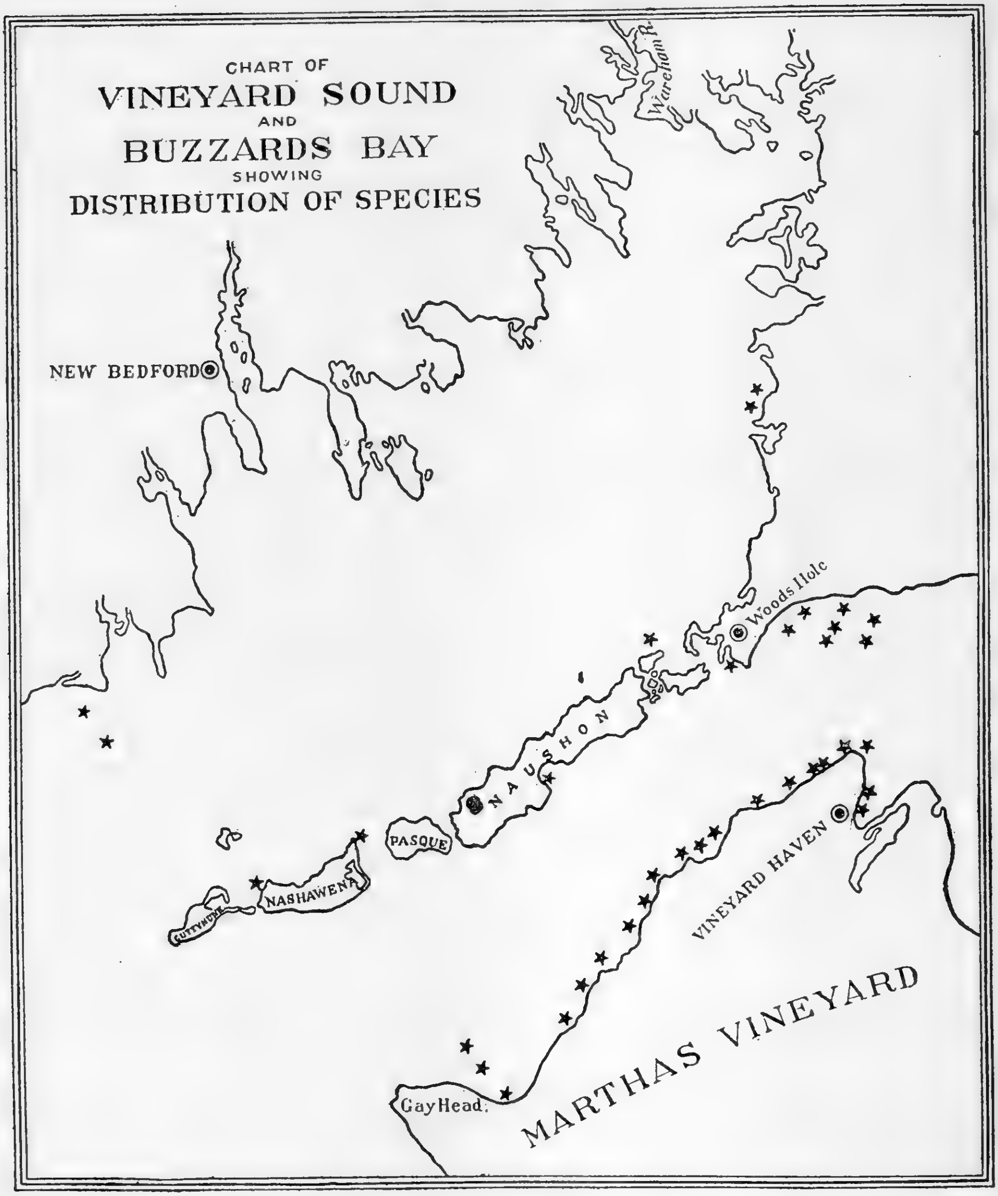

CHART 266.—Zostera marina Linnæus.

This common spermatophyte of the shallow waters presented a scattered distribution, but was unusually abundant off Marthas Vineyard.

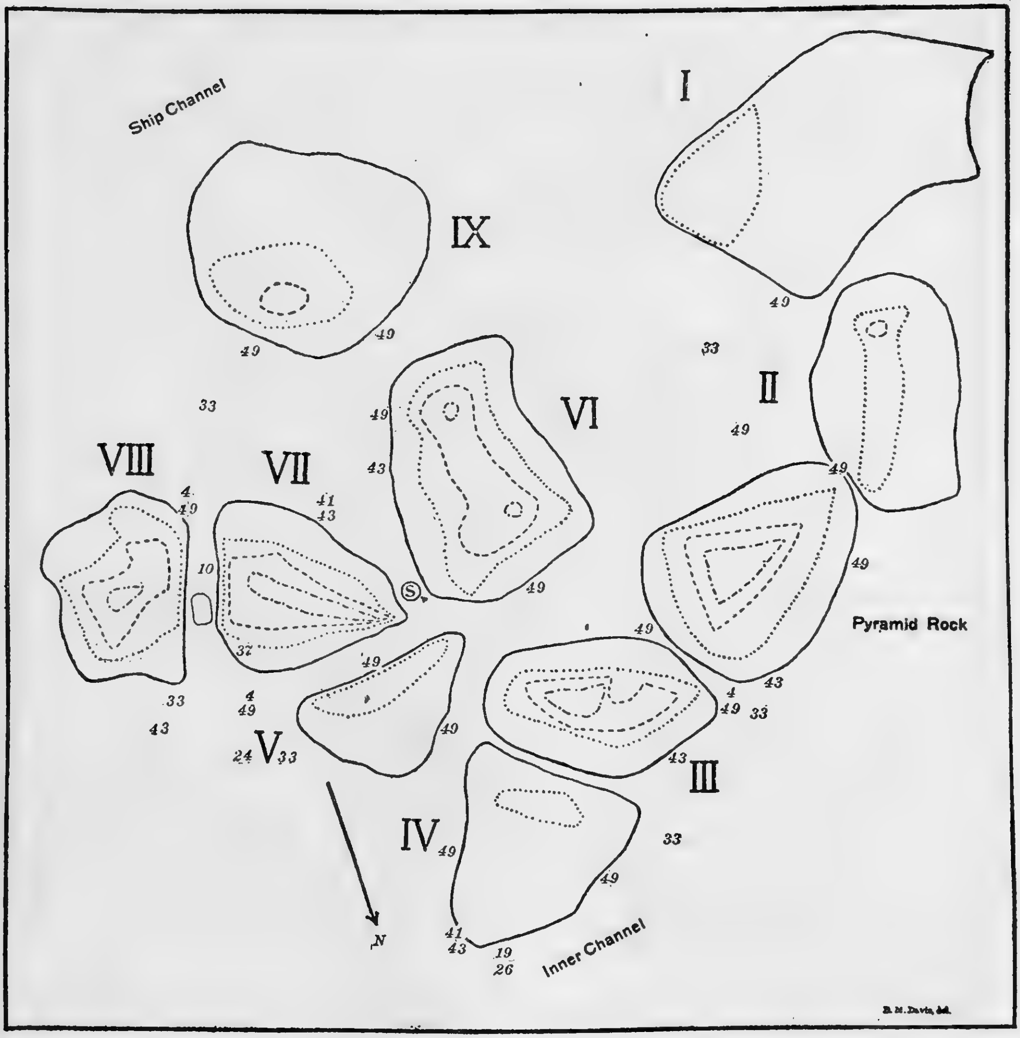

CHART 267.—Distribution of algæ on Spindle Rocks, March 17, 1905.

All the rocks were perfectly bare above low-water mark (the dotted line), having been scraped clean during the winter by floating ice. Algæ were present below low water only in positions where they were protected from contact with the ice. The number of species on the rocks was small in comparison with other seasons of the year, and limited to those that may grow at some depth.

It is interesting to compare the rocks above low-water mark, now entirely bare, with the conditions on December 30, two and one-half months previous (chart 274), for at that date the rocks were covered by growths of *Cladophora lanosa* var. *uncialis* (11), *Phyllitis fascia* (24), and *Scytosiphon lomentarius* (26). The first zone of algæ was well below low water and was composed of *Ceramium rubrum* (43), and *Chondrus crispus* (49), the last extending into deeper water. Somewhat away from the rocks or between them were groups of *Laminaria Agardhii* (33), and occasional growths of *Phyllitis fascia* (24) and *Scytosiphon lomentarius* (26) were present.

List of species: *Ulva Lactuca*, 4, few on *Chondrus; Cladophora lanosa*, 10; *Ectocarpus siliculosus*, 19, on *Scytosiphon; Phyllitis fascia*, 24, few; *Scytosiphon lomentarius*, 26, few; *Laminaria Agardhii*, 33, groups in deep water; *Porphyra laciniata*, 37, occasional; *Callithamnion Baileyi*, 41, on *Ceramium; Ceramium rubrum*, 43, abundant; *Chondrus crispus*, 49, abundant.

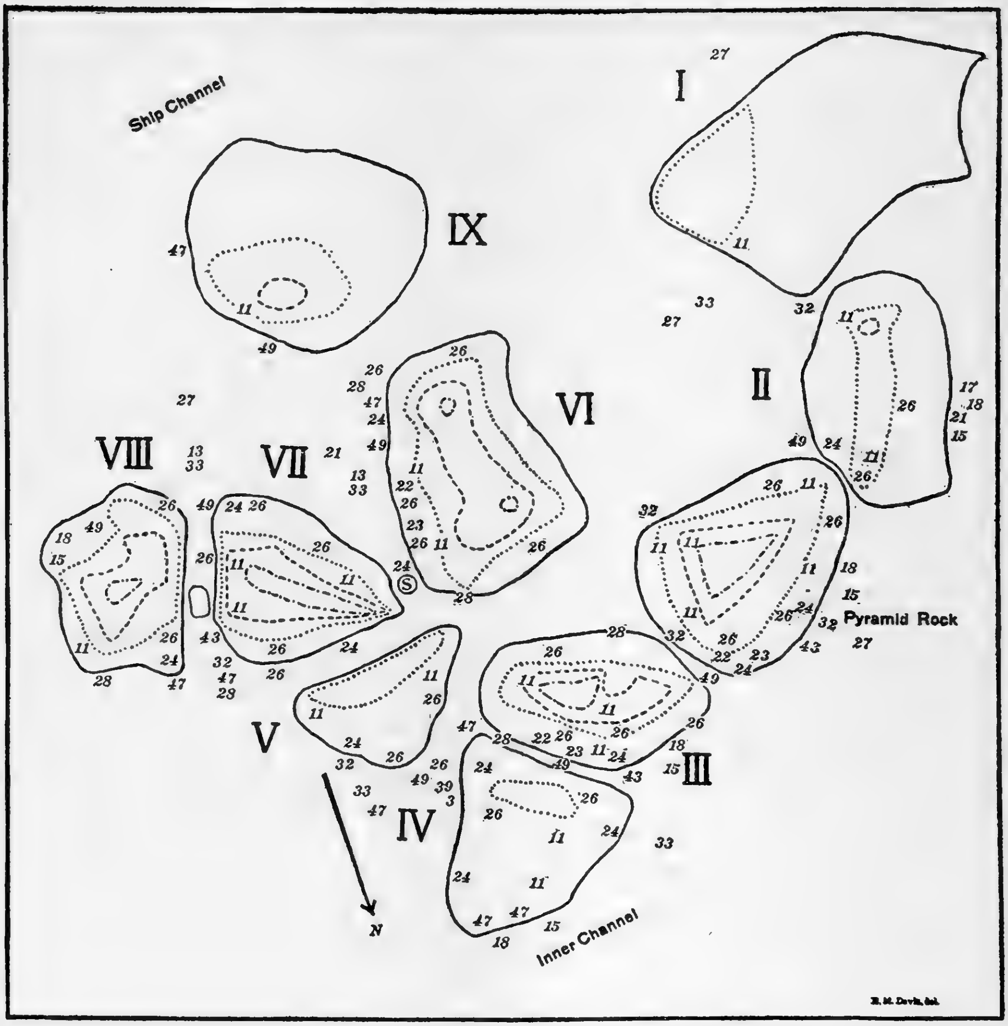

CHART 268.—Distribution of algæ on Spindle Rocks, April 22, 1905.

Rocks still very bare above low-water mark, where they were scraped clean during the winter by floating ice. *Cladophora lanosa* var. *uncialis* (11) formed a green fringe on certain rocks near low-water mark (the dotted line), with the brown algæ *Phyllitis fascia* (24) and *Scytosiphon lomentarius* (26) beginning to appear lower down; this rather imperfect brown zone was composed of young growth and was not very conspicuous at this date. Well below low water were growths of the conspicuous red algæ *Polysiphonia urceolata* (47) and *Chondrus crispus* (49).

List of species: *Cladophora lanosa* var. *uncialis*, 11, very abundant; *Ectocarpus æcidioides*, 13, on old *Laminaria; Ectocarpus fasciculatus*, 15, abundant on larger algæ; *Ectocarpus ovatus*, 17, on mussel shells; *Ectocarpus penicillatus*, 18, very abundant on larger algæ; *Sorocarpus uvæformis*, 21, on mussel shells; *Desmotrichum balticum*, 22, mixed with *Scytosiphon; Desmotrichum undulatum*, 23, mixed with *Scytosiphon; Phyllitis fascia*, 24, young growth on rocks; *Scytosiphon lomentarius*, 26, young growth on rocks; *Desmarestia viridis*, 27, many young plants; *Chordaria flagelliformis*, 28, young plants; *Chorda tomentosa*, 32; *Laminaria Agardhii*, 33; *Acrochætium virgatulum*, 39, on *Ceramium; Ceramium rubrum*, 43; *Polysiphonia urceolata*, 47, abundant; *Chondrus crispus*, 49, abundant.

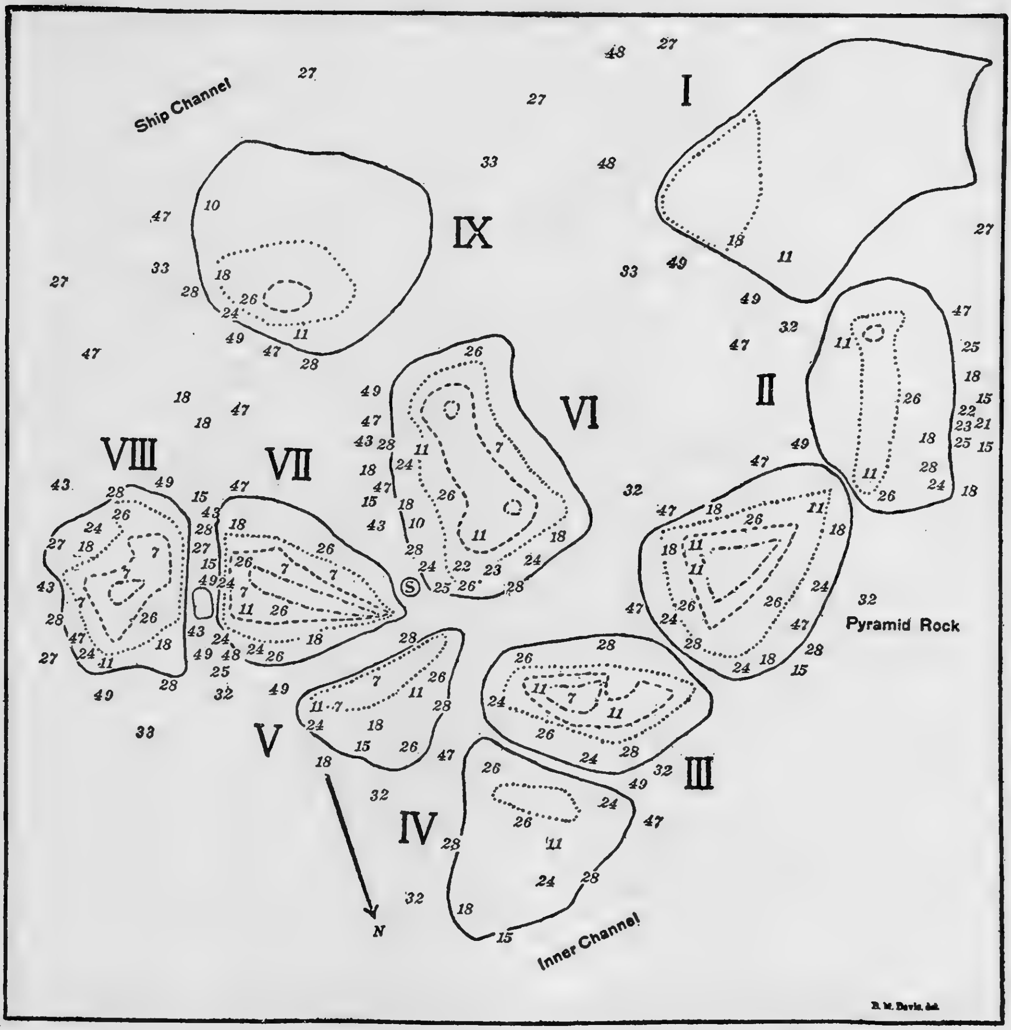

CHART 269.—Distribution of algæ on Spindle Rocks, May 22, 1905.

The rocks at this date presented a characteristic algal flora of the spring at its full development. There was not much change in the species since April 22 (chart 268), but a large increase in the quantity of vegetation. *Cladophora lanosa* var. *uncialis* (11) was still the dominant green alga, but *Enteromorpha intestinalis* (7) had begun to appear; these two species extended the green zone much higher up on the rocks than where it was a month previous (chart 268). The brown zone at low-water mark (the dotted line) and just below, composed chiefly of *Ectocarpus penicillatus* (18), *Phyllitis fascia* (24), *Scytosiphon lomentarius* (26), and *Chordaria flagelliformis* (28), was also broader and more evident. *Polysiphonia urceolata* (47) formed a conspicuous red zone below the brown, with extensive growths of *Chondrus crispus* (49) extending into deeper water.

List of species: *Enteromorpha intestinalis*, 7, young plants; *Cladophora lanosa* var. *uncialis*, 11, abundant; *Ectocarpus fasciculatus*, 15, abundant on larger algæ; *Ectocarpus penicillatus*, 18, abundant on larger algæ; *Sorocarpus uvæformis*, 21, few on mussel shells; *Desmotrichum balticum*, 22, few mixed with *Scytosiphon; Desmotrichum undulatum*, 23, few mixed with *Scytosiphon; Phyllitis fascia*, 24, very abundant; *Punctaria plantaginea*, 25, few; *Scytosiphon lomentarius*, 26, abundant; *Desmarestia viridis*, 27, very abundant; *Chordaria flagelliformis*, 28, much; *Chorda tomentosa*, 32, abundant; *Laminaria Agardhii*, 33; *Ceramium rubrum*, 43, abundant; *Polysiphonia urceolata*, 47, abundant; *Polysiphonia violacea*, 48, few; *Chondrus crispus*, 49, abundant.

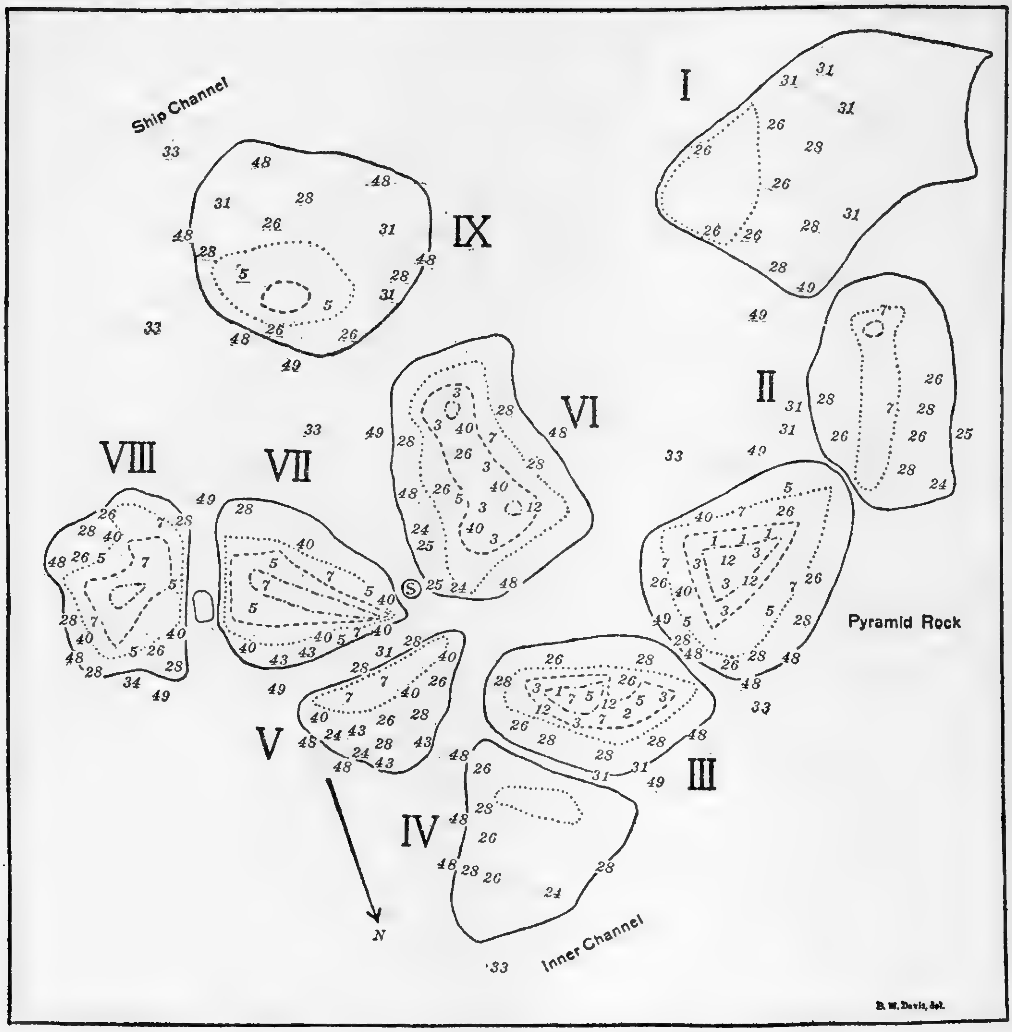

CHART 270.—Distribution of algæ on Spindle Rocks, June 29, 1905.

The character of the vegetation on the rocks had greatly changed from that of May 22 (chart 269), and marked the beginning of the characteristic summer flora and the end of the spring season. A green zone on the upper parts of the rocks was composed chiefly of *Ulothrix implexa* (3), *Ulva Lactuca* var. *rigida* (5), and *Enteromorpha intestinalis* (7); *Cladophora lanosa* var. *uncialis*, formerly so abundant and conspicuous, had entirely disappeared. The brown zone near low-water mark (the dotted line) was composed almost entirely of *Scytosiphon lomentarius* (26), and *Chordaria flagelliformis* (28); *Phyllitis fascia* (24) was only represented by a few old plants, and *Ectocarpus penicillatus* had disappeared. *Polysiphonia urceolata*, so plentiful throughout the spring, was no longer present, but *Polysiphonia violacea* (48) was abundant and with *Ceramium rubrum* (43) formed a fringe around the rocks a little below low-water mark with *Chondrus crispus* (49) in deeper water. *Nemalion multifidum* (40) had begun to appear at and above low-water mark.

List of algæ: *Calothrix scopulorum*, 1, in small patches; *Ulothrix implexa*, 3, covering the top of III, VI, and Pyramid Rock; *Ulva Lactuca* var. *rigida*, 5, abundant young growths; *Enteromorpha intestinalis*, 7, much; *Codiolum gregarium*, 10, abundant on barnacles; *Phyllitis fascia*, 24, few old plants; *Punctaria plantaginea*, 25, few; *Scytosiphon lomentarius*, 26, abundant; *Chordaria flagelliformis*, 28, very abundant; *Chorda filum*, 31; *Laminaria Agardhii*, 33, scattered plants; *Laminaria Agardhii* var. *vittata*, 34, small group; *Nemalion multifidum*, 40, young growth; *Ceramium rubrum*, 43, few; *Polysiphonia violacea*, 48, abundant; *Chondrus crispus*, 49, abundant.

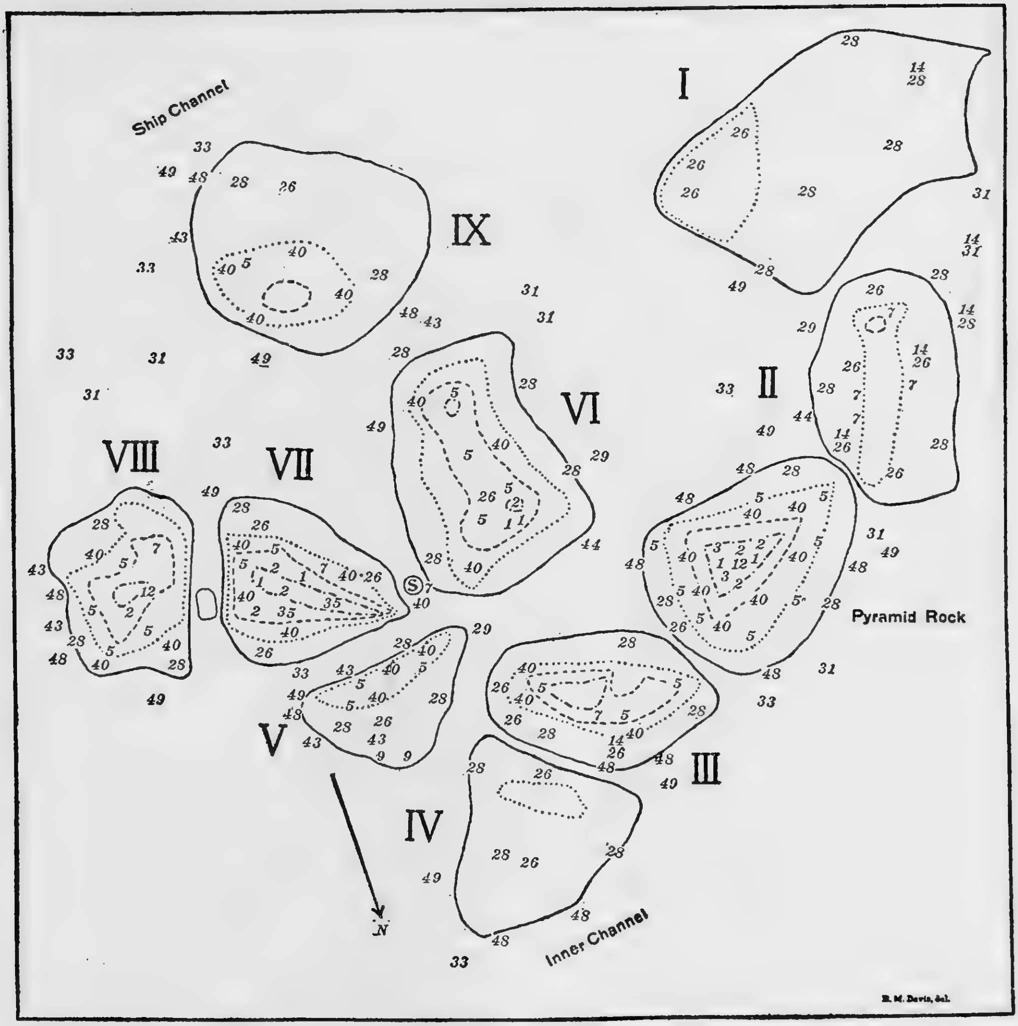

CHART 271.—Distribution of algæ on Spindle Rocks, July 22, 1905.

The only conspicuous green alga was *Ulva Lactuca* var. *rigida* (5), now full grown and forming large patches on some of the rocks. There was a very well-defined brown zone just below low-water mark (the dotted line) composed of *Chordaria flagelliformis* (28) and old *Scytosiphon lomentarius* (26). *Ectocarpus confervoides* (14) was plentiful on the *Chordaria* and *Scytosiphon*. *Phyllitis fascia* had disappeared. *Nemalion multifidum* (40) fringed most of the rocks at low-water mark, and below was a characteristic red zone of *Polysiphonia violacea* (48) and *Ceramium rubrum* (43) mixed with the *Chordaria*, and with *Chondrus crispus* (49) abundant from 1–5 feet below low water.

List of algæ: *Calothrix scopulorum*, 1, small patches on barnacles and rocks; *Rivularia atra*, 2, on barnacles; *Ulothrix implexa*, 3, on Pyramid Rock; *Ulva Lactuca* var. *rigida*, 5, abundant on tops of rocks; *Enteromorpha intestinalis*, 7, few patches; *Cladophora gracilis*, 9, few tufts; *Codiolum gregarium*, 12, on barnacles; *Ectocarpus confervoides*, 14, abundant on *Chordaria* and *Scytosiphon*; *Scytosiphon lomentarius*, 26, much old growth; *Chordaria flagelliformis*, 28, abundant; *Mesogloia divaricata*, 29, few patches; *Chorda filum*, 31, large patches; *Laminaria Agardhii*, 33, few groups; *Fucus vesiculosus*, 35, few plants; *Nemalion multifidum*, 40, abundant; *Ceramium rubrum*, 43, abundant; *Chondria dasyphylla*, 44, few plants; *Polysiphonia violacea*, 48, abundant; *Chondrus crispus*, 49, abundant.

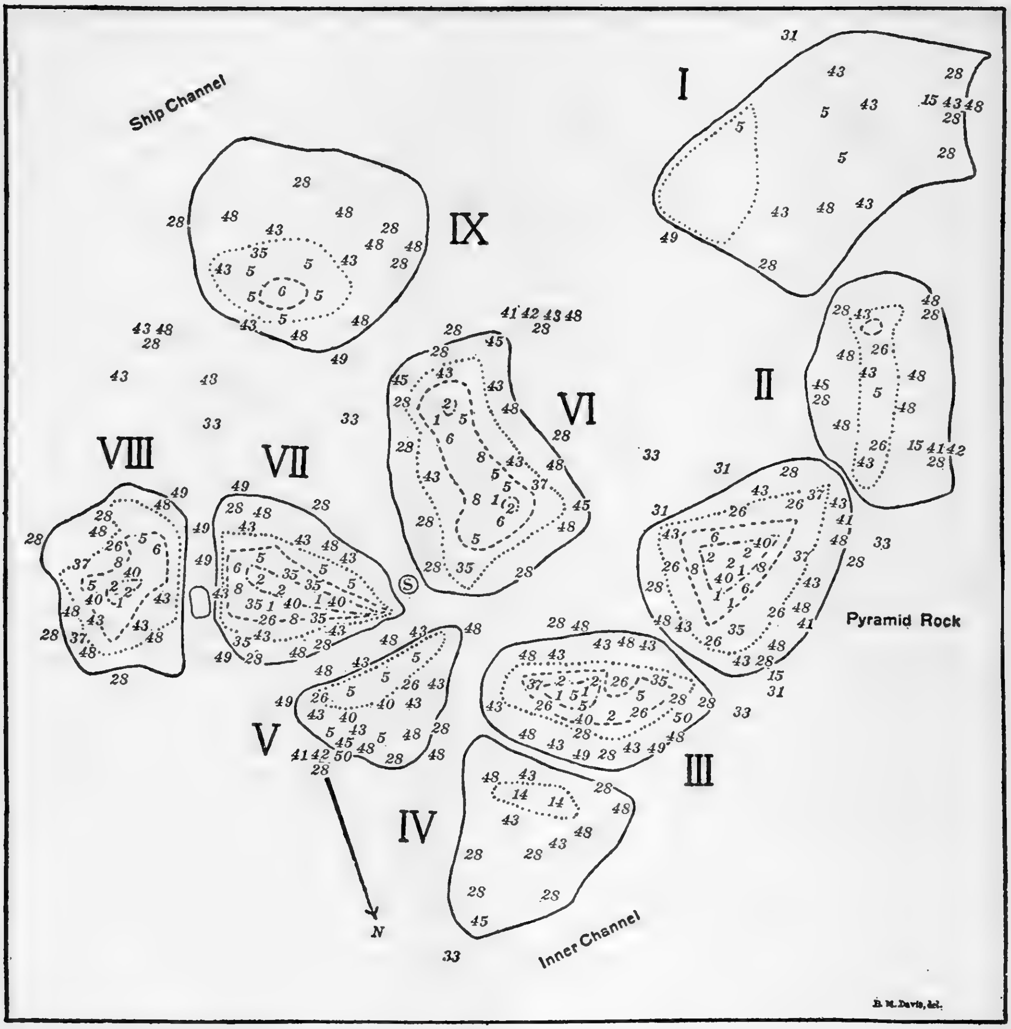

CHART 272.—Distribution of algæ on Spindle Rocks, September 2, 1905.

The rocks on September 2 presented an aspect similar to that on July 22 (chart 271) with some features, however, more pronounced. The prevailing green alga was *Ulva Lactuca* var. *rigida* (5) forming large patches on the tops of rocks. The most conspicuous brown algæ were *Chordaria flagelliformis* (28), growing in large masses, sometimes as a zone below low-water mark (the dotted line), and old *Scytosiphon lomentarius* (26) forming patches higher up on the rocks. The most conspicuous zone (much more pronounced than in chart 271) was that near low-water mark composed of *Ceramium rubrum* (43) and *Polysiphonia violacea* (48). There was much less *Nemalion multifidum* (40), which, however, formed a zone on rocks V, VII, and VIII. *Chondrus crispus* (49) was plentiful in deeper water below the *Chordaria*.

List of algæ: *Calothrix scopulorum*, 1, small patches on barnacles and rocks; *Rivularia atra*, 2, on barnacles; *Ulva Lactuca* var. *rigida*, 5, plentiful on tops of rocks; *Enteromorpha crinita*, 6, few plants; *Enteromorpha prolifera*, 8, few plants; *Ectocarpus confervoides*, 14, on old plants of *Scytosiphon; Ectocarpus fasciculatus*, 15, abundant on *Chordaria* and *Chorda; Scytosiphon lomentarius*, 26, patches of old plants; *Chordaria flagelliformis*, 28, abundant; *Chorda filum*, 31, large patches; *Laminaria Agardhii*, 33, occasional plants; *Fucus vesiculosus*, 35, scattered plants; *Porphyra laciniata*, 37, scattered plants; *Nemalion multifidum*, 40, abundant; *Callithamnion Baileyi*, 41, many on *Chordaria; Callithamnion corymbosum*, 42, many on *Chordaria; Ceramium rubrum*, 43, very abundant; *Dasya elegans*, 45, occasional plants; *Polysiphonia violacea*, 48, very abundant; *Chondrus crispus*, 49, abundant; *Champia parvula*, 50, occasional on *Chordaria* and rocks.

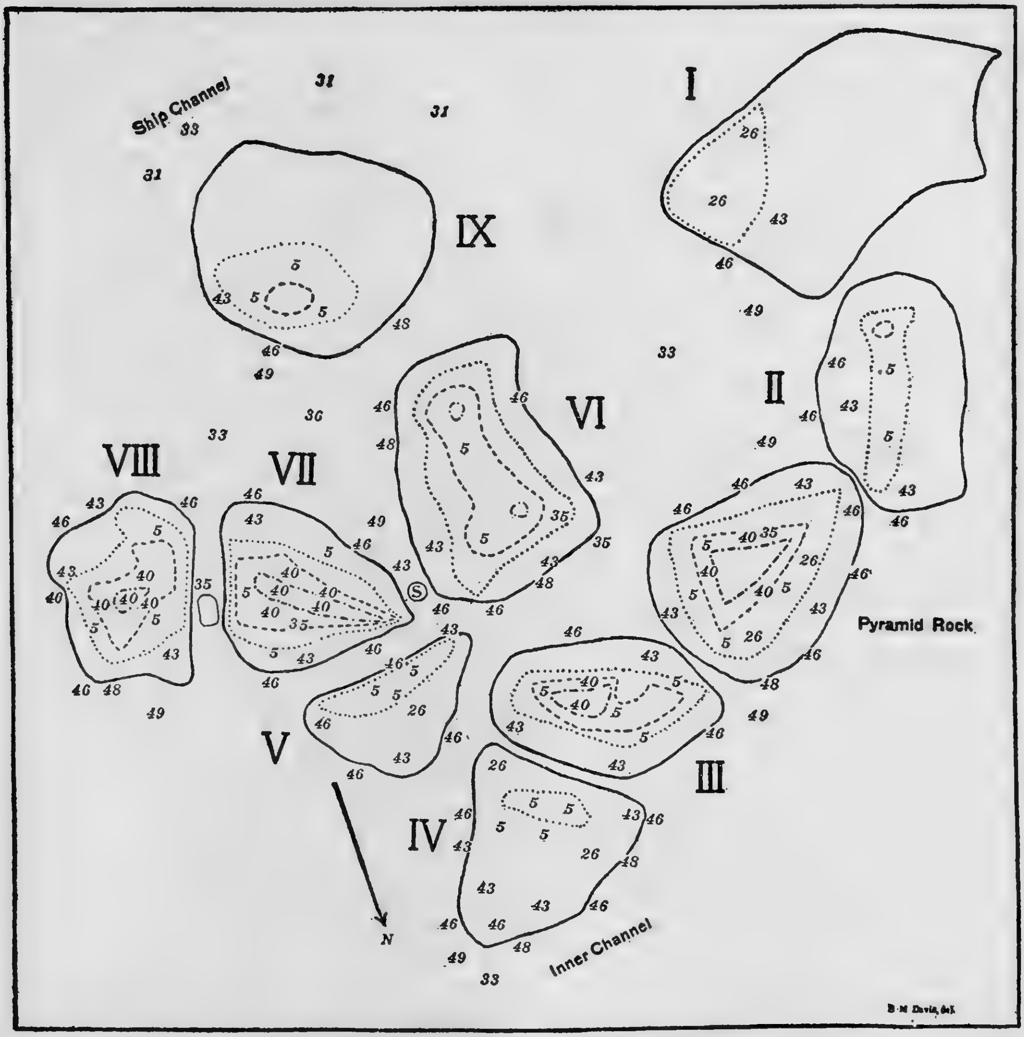

CHART 273.—Distribution of algæ on Spindle Rocks, September 19, 1904.

This chart is introduced to show variations that may be present in the algal life on the same rocks at the same season but in different years. It should be compared with chart 272, plotted September 2, 1905. The charts agree in having *Ulva Lactuca* var. *rigida* (5) as the conspicuous green alga on the tops of the rocks. There was no *Chordaria flagelliformis* this season and consequently no zone of brown algæ, although *Scytosiphon lomentarius* (26) grew in scattered patches. *Nemalion multifidum* (40) formed a zone of thick growth above low-water mark (the dotted line) on rocks III, VII, VIII, and Pyramid Rock. The most conspicuous zone was below low water and composed of *Ceramium rubrum* (43) and *Polysiphonia fibrillosa* (46). The *Polysiphonia fibrillosa*, which was not present at all in 1905, this season took the place of *Chordaria flagelliformis* and *Polysiphonia violacea* (48), usually abundant, but scattered plants of the latter were present. *Chondrus crispus*, as usual, was abundant, extending into deeper water below the *Polysiphonia*.

List of species: *Ulva Lactuca* var. *rigida*, 5, abundant; *Scytosiphon lomentarius*, 26, patches on rocks; *Chorda filum*, 31, large beds; *Laminaria Agardhii*, 33, scattered patches; *Fucus vesiculosus*, 35, scattered plants, *Sargassum Filipendula*, 36, few plants; *Nemalion multifidum*, 40, abundant; *Ceramium rubrum*, 43, abundant; *Polysiphonia fibrillosa*, 46, very abundant, fringing rocks just below low-water; *Polysiphonia violacea*, 48, few; *Chondrus crispus*, 49, abundant.

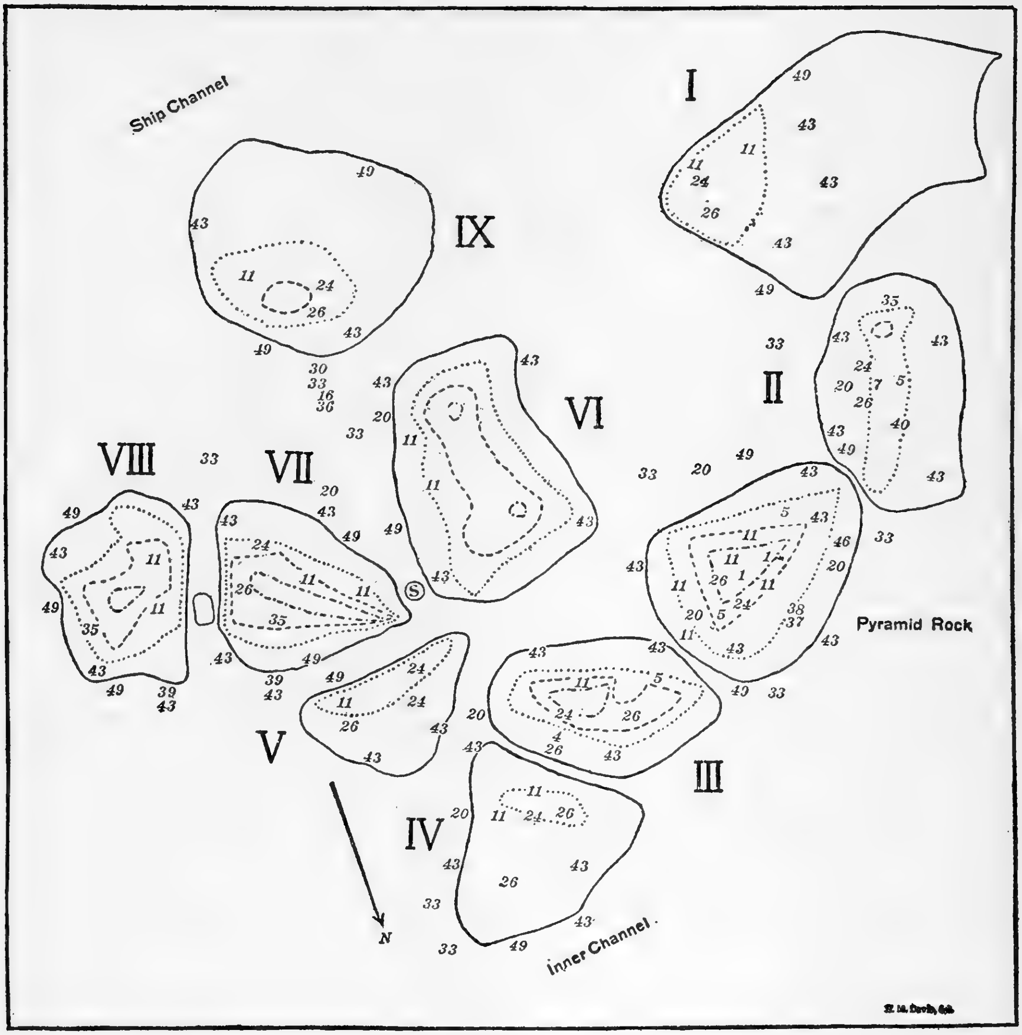

CHART 274.—Distribution of algæ on Spindle Rocks, December 30, 1904.

This chart plots the vegetation on the rocks in the winter before the upper parts are scraped clean by floating ice. In the series of charts it shows the conditions two and one-half months before those presented on chart 267. The prevailing green alga was *Cladophora lanosa* var. *uncialis* (11), present on the upper portions of every rock above low-water mark (the dotted lines). Near low-water mark was a brown zone of *Phyllitis fascia* (24) and *Scytosiphon lomentarius* (26). *Phyllitis fascia*, which disappears in the summer, had returned in abundance. Below low water was a red zone of *Ceramium rubrum* (43), very plentiful, and in deeper water was the ever-present *Chondrus crispus* (49). *Polysiphonia fibrillosa* (46), so abundant September 19 (chart 273), had almost disappeared, and there was no *Polysiphonia violacea*, generally characteristic of the summer. Only a few plants of *Nemalion multifidum* (40) remained.

List of algæ: *Calothrix scopulorum*, 1, patches on the top of Pyramid Rock; *Ulva Lactuca* var. *rigida*, 5, bases of old plants; *Enteromorpha intestinalis*, 7, few scattered plants; *Cladophora lanosa* var. *uncialis*, 11, abundant on the top of every rock; *Ectocarpus granulosus*, 16, abundant on *Sargassum* and other large algæ below low-water; *Ectocarpus tomentosus*, 20, abundant on larger algæ below low-water; *Phyllitis fascia*, 24, abundant above low-water; *Scytosiphon lomentarius*, 26, very abundant above low-water; *Myrionema corunnæ*, 30, on *Laminaria; Laminaria Agardhii*, 33, many old plants; *Fucus vesiculosus*, 35, few scattered plants; *Sargassum Filipendula*, 36, few young plants; *Porphyra laciniata*, 37, scattered plants; *Acrochætium secundatum*, 38, on *Porphyra; Acrochætium virgatulum*, 39, on *Ceramium; Nemalion multifidum*, 40, few plants; *Ceramium rubrum*, 43, very abundant; *Polysiphonia fibrillosa*, 46, few plants; *Chondrus crispus*, 49, abundant.